United States
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Soil
Conservation
Service

Denver
Colorado

MISSOURI RIVER TRIBUTARIES, COLORADO
COOPERATIVE RIVER BASIN STUDY

POTENTIAL FOR IRRIGATION SYSTEM IMPROVEMENTS

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Sponsored by
Colorado Water Conservation Board

Soil Conservation Service
Denver, Colorado

September 1986

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PREFACE

The State of Colorado, through the Colorado Water Conservation Board (CWCB), requested the U.S. Department of Agriculture (USDA) to participate in a cooperative river basin study of the Missouri River Tributary, River Basin in Colorado by letter on October 17, 1980. The objectives of this study are to identify resources, determine needs, and present alternative solutions to assist decisionmakers in the orderly development of water and related land resources of the area.

USDA participation in the cooperative river basin study is authorized under Section 6, Public Law 83-566, as amended. Authorization for the study as described in the study plan was given on June 1, 1981. The principal USDA participants are the Soil Conservation Service (SCS), Economic Research Service (ERS), and the Forest Service (FS). The Colorado Water Conservation Board also participated in the study.

The Colorado Field Advisory Committee (FAC) composed of representatives from the SCS, ERS, FS and CWCD provided the direction and overall management for the study. Study activities were carried out by personnel assigned from the various agencies as outlined in the Study Plan. Liaison with other state agencies was provided by the CWCB staff.

Additional information about the Missouri River Tributary, Colorado River Basin Study should be requested from:

State Conservationist
Soil Conservation Service
Diamond Hill, Bldg A, 3rd Floor
2490 West 26th Avenue
Denver, Colorado 80211 (303) 964-0295

SUMMARY

The Colorado Water Conservation Board, acting for the State of Colorado, requested the Department of Agriculture to conduct a cooperative river basin study of the Missouri River Tributaries within Colorado. This included the North and South Platte River Basins along with the Republican River Basin. It was agreed that the objective of this cooperative study would be to address the water resource problems found in individual irrigation systems and to develop alternatives that will improve their productivity, water use efficiency and water management. A sample of representative irrigation systems was used in the study.

Twenty-three systems were selected for detailed study. In each of these systems, the canal company and other local officials were interviewed. A list of problems was developed. Alternatives were developed to address the problems identified.

Monetary and non-monetary benefits used in comparing the feasibility of alternatives for each system include the following:

1. Onfarm water conservation benefits.

    a) reduce costs of production such as labor, water costs including pumping, surface water and purchased water, and operation, maintenance and replacement costs for onfarm ditch systems and laterals.
    b) reduce water shortages which improve yields as well as conversion to higher income crops.
    c) reduce erosion and sediment costs.
    d) reduce soil salinity and high water table damages.
    e) reduce tailwater damages from weeds and pests.
    f) improve irrigation systems through improved designs.

2. Off-farm water conservation benefits.

    a) improve instream flow.
    b) reduce operation, maintenance and replacement costs.
    c) stabilize the agricultural economy of the area.

Table S-1 summarizes the identified needs and feasible improvements. A computer model was developed and used to analyze and compare alternatives for each system studied.

Table S-1 Identified Needs and Economically Feasible Improvements for 23 Sample Irrigation Systems 1/

Missouri River Basin, Colorado

Item	Unit	Identified Need	Feasible Improvements
Canal			
Reservoir Imp.	No.	6	2
Lining	Miles	109	26.6
Pipeline	Miles	10	0
Diversion Str.	No.	10	2
Water Control Str.	No.	1,002	13
Onfarm			
Ditch Lining	Miles	310	122
Pipeline	Miles	169	63
Water Cont. Str.	No.	1,275	607
Land Level	Ac.	17,550	8,200
Irr. Water Mgt. 2/	Ac.	264,199	264,199
Convert Irr. Method 3/	Ac.	13,500	8,400
Cons. Crop System 4/	Ac.	6,500	3,000

1/ Sample of 25 percent of predominantly surface water supplied systems.

2/ This is a non-structural practice involving improvements such as: irrigation scheduling, time of irrigation set, optimum stream size, tailwater management.

3/ Change from surface systems to sprinkler systems.

4/ Non-structural practices of management of crop residue.

Systems studied supply water to over 264,000 acreas, this is about 25 percent of all the land irrigated with surface water supplies. Based upon this sample it can be concluded that structural practices will be difficult to economically justify. The five systems, in which structural improvement were justified, had an inadequate water supply. In these systems small changes in efficiencies produced large changes in crop productions. Irrigation water management proved to be economically justified in all systems studied. From this it is concluded that improved management is needed through out the basin. There were also 2 systems found to have viable onfarm structural needs.

Over 58 million dollars will be needed to construct the improvements found to be economically feasible in the systems studied. About four times that amount is needed to provide needed improvements through out the basin. Some loans and grants may be available from the State and Federal governments to assist in implementing these projects.

PROBLEMS AND CONCERNS

Introduction

The Colorado Water Conservation Board, acting for the State of Colorado, requested the Department of Agriculture to conduct a cooperative river basin study of the Missouri River Tributaries within Colorado. This includes the North and South Platte River Basins along with the Republican River Basin.

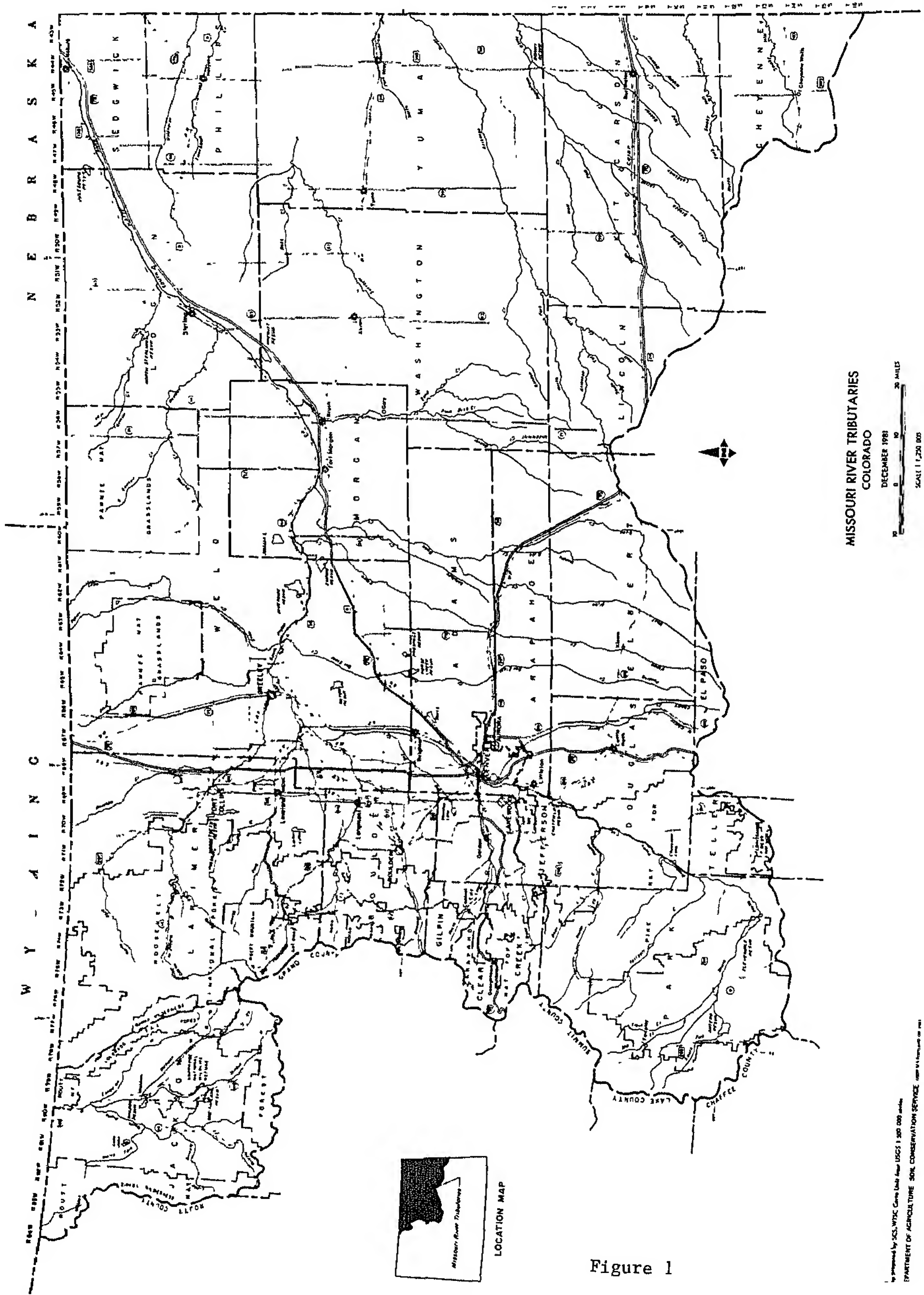
The CWCB's request stems from its legislative authority which charges them with these responsibilities: (1) to promote the conservation of the waters of the State of Colorado in order to secure the greatest utilization of such waters and the utmost prevention of floods, and (2) to cooperate with the United States and agencies thereof, and with other states for the purpose of bringing about the greatest utilization of the waters of the State of Colorado and the prevention of flood damages.

Data developed by the study will enable farmers and irrigation companies, with USDA and state assistance, to improve their productivity, water use efficiency, and water management. As a result, the social, environmental, and economic stability of the area should be improved.

Description of Basin

The study area contains all of the North and South Platte Rivers and Republican River drainages within Colorado. Figure 1 shows the location of the study area. The Platte River drainage contains both the North and South Platte River Basins. The Republican River drainage includes the Frenchman, Arikaree, South Fork of the Arikaree, North and South Forks of the Republican, and the Smoky Hill River drainages. The total area is approximately 19,121,000 acres. Table B-1 in Appendix B shows the land use in the major basins.

Land forms range from mountain peaks, 14,000 feet in elevation to the rolling prairie of eastern Colorado with an average elevation of 4,000 feet above mean sea level. Major urban centers of Denver, Boulder, Ft. Collins and Greeley are located within the area. It is estimated that 1,986,603 people lived in the area in 1980. The front range, comprising the eastern slope of the Rocky Mountains in Colorado, is experiencing very rapid growth in population. Surface irrigation water is supplied from the South Platte, with augmentation from the Colorado River Systems via interbasin transfers; North Platte, and Republican Rivers. Groundwater is obtained from shallow aquifers connected with the South Platte River and from the Ogallala Aquifer. Additional resource data may be found in Appendices A-G.



MISSOURI RIVER TRIBUTARIES
COLORADO
DECEMBER 1981
LOCATION MAP
Missouri River Tributaries
N E B R A S K A
W Y O M I N G
SEDGWICK
PHILLIPS
YUMA
WASHINGTON
MORGAN
WELD
LOGAN
KIT CARSON
CHEYENNE
LINCOLN
ELBERT
ADAMS
ARAPAHOE
DOUGLAS
JEFFERSON
BOULDER
LARIMER
GILPIN
CLEAR CREEK
JACKSON
PARK
TELLER
EL PASO
GRAND COUNTY
SUMMIT COUNTY
LAKE COUNTY
CHAFFEE COUNTY
ROUTT COUNTY
PAWNEE NAT GRASSLANDS
7-EN-24

Figure 1

On-going Studies

Many different agencies and groups have made and are making water resource studies in the South Platte and Republican River Basins. The Colorado Water Conservation Board is conducting a study to identify alternative uses and combinations of uses for the state's remaining share of the South Platte River water. The Corps of Engineers has just completed the Metropolitan Denver and South Platte River Basin, Colorado Flood Control Study. The Urban Drainage and Flood Control District has a continuing Master Planning Program for Denver. The State of Colorado is developing Phase III of the Colorado State Water Plan. The Bureau of Reclamation is continuing with its Front Range Unit, which is a study of municipal and industrial (M&I) water supply problems in part of the basin. The U. S. Forest Service and the Colorado State Forest Service are currently developing long range plans for multiple use forestry. This planning includes special studies for Wild and Scenic River classification as required by Congress.

A six state study under the leadership of the Economic Development Administration was completed which investigated the extent of groundwater depletion of the Ogallala Aquifer and its impacts upon High Plains agriculture, and made recommendations for action.

Problems and Objectives

The objective of this cooperative study is to address the water resource problems and opportunities found in individual irrigation systems and to develop alternatives that will improve their productivity, water use efficiency and water management. This study objective was agreed upon after meeting with State officials and local leaders. They indicated that while many problems related to water resources exist in the Basin, individual system planning is the most critical need not already studied by other agencies or groups. A literature review indicated that while there are many water resource studies of the basin, none exist that identify the needs of the private irrigation systems. The available information found during the literature review on water use, flooding, erosion, land conversion, the basin river system, etc., was useful in this study.

Most of the surface irrigation systems were developed in the late 1800's. Little change has been made in the systems over time. The useful life of many of the water control structures has expired. Repairs to extend the structures life can be found in many systems. As a general rule the irrigation companies have not invested the funds needed to adequately maintain their systems. Few companies have a replacement program to update their water control structures. A number of irrigation systems have had storage restrictions placed on them because of dam safety regulations. Water loss from canal seepage is recognized as a problem, but the irrigation companies have been unwilling to invest the large amount of funds needed to line canals. In most areas, the water loss from canal seepage is not a loss to the river system, but it is to the initial water user. Canal conveyance efficiencies range from 47-73% in the basin.

Low onfarm irrigation water efficiency (30-50%) is not generally recognized by farmers as a problem. Irrigators use the amount of water they have available, when it is available. The amount of labor use for irrigation is perceived as being more important than the amount of water used. Onfarm irrigation improvements are installed to reduce the labor needs.

A significant percent of irrigation systems in the basin do not have adequate water for the acres of cropland and pasture served. Crops that receive only a partial water supply will not produce up to capability. Therefore millions of dollars of crop production benefits are lost as a result of water shortages in the basin. The following data of one selected system helps illustrate this problem: 1/

Selected Irrigation System -

Cropland served:	16,000	ac. alfalfa
	23,892	ac. corn
	10,000	ac. pasture
	49,892	ac. Total

Water supply:

Diverted	45,000 ac/ft
Reservoir and purchased	52,000 ac/ft
Pumped	7,952 ac/ft
	104,952 ac/ft

Estimated System Efficiency - 30.7 %
(Conveyance and on-farm)

Water Supply Available for Crop Consumptive Use - 32,218 ac/ft (0.65 ac.ft/ac)

Irrigation Requirement of Crops (full supply) - 77,163 ac/ft (1.55 ac.ft/ac)

Irrigation Water Shortage - 44,945 AF (58%)

Crop Yields	Predicted yields by the model for "Future Without" conditions	Possible with full water conditions 2/
alfalfa	3.41 ton/ac	5.50 ton/ac
corn	138.56 bu/ac	140 bu/ac
pasture	7.00 AUM	7.5 AUM

Table A summarizes the system improvements believed by the irrigation companies to be needed in the 23 systems studied. While the quantities may vary for other systems in the basin, the same type of needs exist in most systems within the basin. See individual reports for seriousness of problems for each system.

1/ See Appendix J for a more complete analysis.
2/ These yields could be further increased by applying management practices not specifically related to water shortages.

Table A Identified Needs for 23 Sample Irrigation Systems 1/
Missouri River Basin, Colorado

Item	Unit	Identified Need
Canal		
Reservoir Imp.	No.	6
Lining	Miles	109
Pipeline	Miles	10
Diversion Structures	No.	10
Water Cont. Str.	No.	1,002
Onfarm		
Ditch Lining	Miles	310
Pipeline	Miles	169
Water Cont. Str.	No.	1,275
Land Leveling	Ac.	17,550
Irr. Water Mgt. 2/	Ac.	264,199
Convert Irr. Method 3/	Ac.	13,500
Cons. Crop System 4/	Ac.	6,500

1/ Sample of 25 percent of predominantly surface water supplied systems.
2/ This is a non-structural practice involving improvements such as: irrigation scheduling, time of irrigation set, optimum stream size, and/or tailwater management.
3/ Change from surface systems to sprinkler systems, cablegation and surge irrigation.
4/ Non-structural practices of management of crop residues.

SYSTEMS STUDIED

Introduction

In reviewing the number of irrigation systems for the Missouri Tributaries River Basin study, the conclusion was made that not all the systems in the basin could be studied. The following procedure was used to prioritize ditch systems as follows:

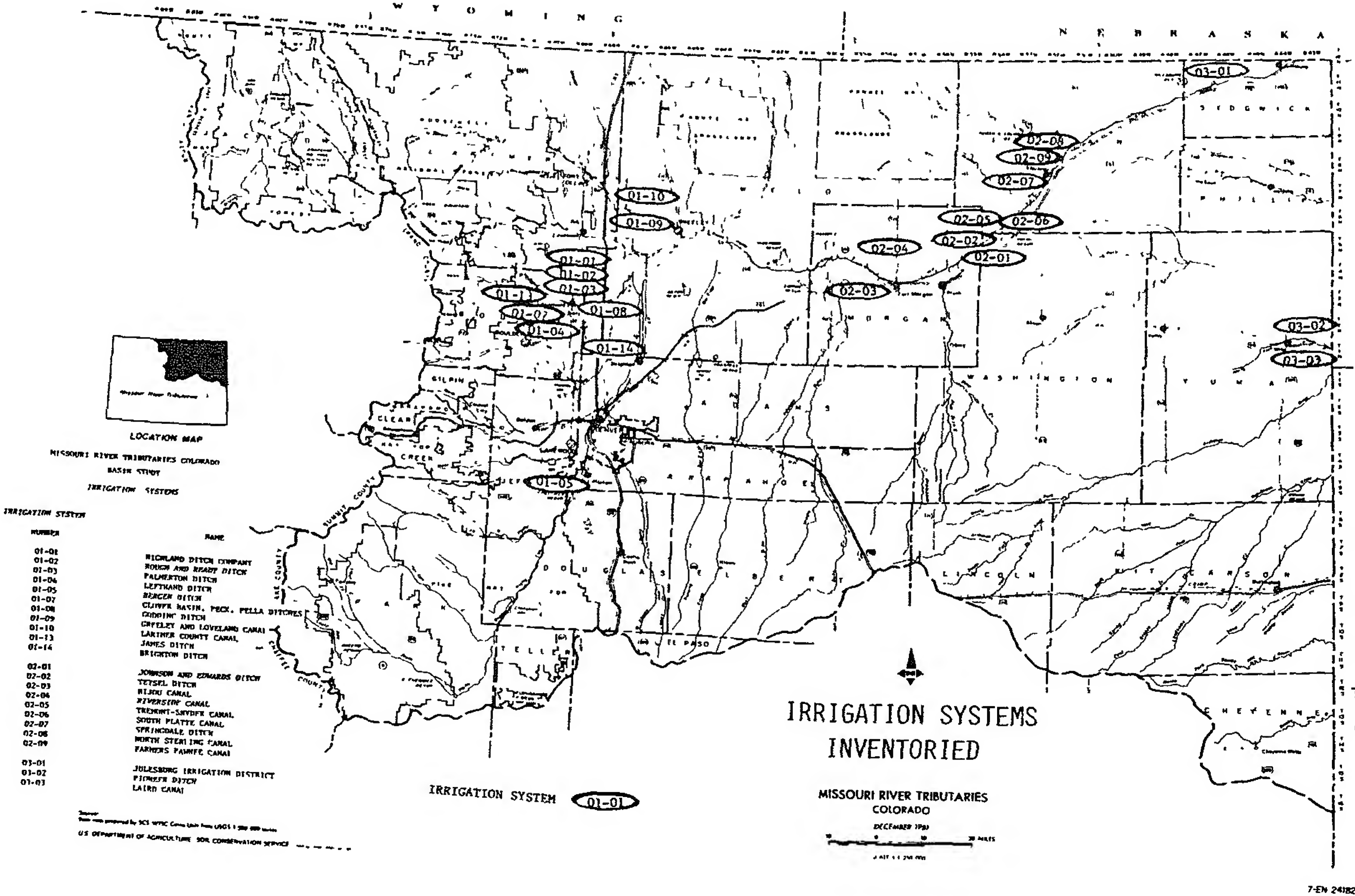
Each SCS field office, with help from the Soil Conservation Districts (SCD) rated the systems within their district. Each field office selected up to 10 ditch systems that have the best opportunities to implement improvement. An irrigation worksheet was developed by the SCS to compare systems within the field offices. A workshop was held to explain the use of the worksheet.

Once the evaluation worksheets were completed, a committee of SCS area and state office staffs compared the systems between field offices. Care was taken so that at least 1 system was chosen from each part of the Missouri River Tributaries. See Appendix H for evaluation worksheet.

In-depth data for the analysis was obtained on each irrigation system from ditch company personnel, field office employees, and some farmers.

Systems Description:

The objective of this study was to address water resource problems found on the twenty three (23) individual irrigation systems throughout the basin. These systems are representive of the water resource problems throughout the basin. (See map on next page)


IRRIGATION SYSTEMS INVENTORIED
MISSOURI RIVER TRIBUTARIES
COLORADO
DECEMBER 1981
IRRIGATION SYSTEM 01-01
LOCATION MAP
MISSOURI RIVER TRIBUTARIES COLORADO
BASIN STUDY
IRRIGATION SYSTEMS
IRRIGATION SYSTEM
NUMBER
NAME
01-01 RICHLAND DITCH COMPANY
01-02 ROUGH AND READY DITCH
01-03 PALMERTON DITCH
01-04 LEFTHAND DITCH
01-05 BERGEN DITCH
01-07 CLOVER BASIN, PECK, PELLA DITCHES
01-08 GOODING DITCH
01-09 GREELEY AND LOVELAND CANAL
01-10 LARIMER COUNTY CANAL
01-13 JAMES DITCH
01-14 BRIGHTON DITCH
02-01 JOHNSON AND EDWARDS DITCH
02-02 TETSEL DITCH
02-03 BIJOU CANAL
02-04 RIVERSIDE CANAL
02-05 TREMONT-SNYDER CANAL
02-06 SOUTH PLATTE CANAL
02-07 SPRINGDALE DITCH
02-08 NORTH STERLING CANAL
02-09 FARMERS PAWNEE CANAL
03-01 JULESBURG IRRIGATION DISTRICT
03-02 PIONEER DITCH
03-03 LAIRD CANAL
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
WYOMING
NEBRASKA
KANSAS
SEDGWICK
PHILLIPS
LOGAN
MORGAN
WASHINGTON
YUMA
WELD
ADAMS
ARAPAHOE
DOUGLAS
ELBERT
LINCOLN
KIT CARSON
CHEYENNE
EL PASO
TELLER
GILPIN
CLEAR CREEK
SUMMIT COUNTY
CHAFFEE COUNTY
7-EN 24182

01-01 HIGHLAND DITCH COMPANY - is located in Boulder and Weld Counties, Colorado. It serves 35,000 acres of irrigated cropland on the north side of the St. Vrain Creek at Longmont, Colorado. The water source is a diversion on St. Vrain Creek at Lyons, Colorado. It carries direct diversions along with water for storage. The Highland system has a transmission ditch approximately 21 miles long with six (6) storage reservoirs. Two of these storage reservoirs are exchange reservoirs and are not located on the Highland System (Foothills Reservoir and McIntosh Lake). Three reservoirs are on the Highland Ditch System (Highland No. 1, No. 2, and No. 3) below the diversion point. Beaver Park Reservoir is located on the upper head waters, south of Rocky Mountain National Park.

The Highland Ditch Company serves approximately 250 farms. The needs of the canal include work on Beaver Park outlet works, and water-control structures and canal lining of high seepage areas.

The onfarm needs include ditch lining, farm pipelines, water-control structures, land leveling, irrigation water management (IWM) and irrigation method changes.

01-02 ROUGH AND READY DITCH - is located in Boulder County, Colorado. It serves 500 acres of irrigated cropland on the north side of St. Vrain Creek at Longmont, Colorado. The water source is a diversion on St. Vrain Creek at Lyons, Colorado. It carries water for storage along with direct diversions. There are 16.4 miles of canal in this system. The canal needs include water-control structures and canal lining of high seepage areas.

The onfarm needs include ditch lining, water-control structures, and irrigation water management.

01-03 PALMERTON DITCH - is located in Boulder County, Colorado. It serves 60 acres of irrigated cropland on the north side of St. Vrain Creek at Longmont, Colorado. The water source is a diversion on St. Vrain Creek at Lyons, Colorado. It also carries water to Longmont Pipeline. There are 5.5 miles of canal in this system. The canal needs include turnouts and checks and canal lining of high seepage areas.

The onfarm needs include water-control structures, farm pipeline, and irrigation water management.

01-04 LEFTHAND DITCH - is located in Boulder County, Colorado. It serves 13,342 acres of irrigated cropland on both sides of Lefthand Creek (which is Lefthand Ditch). The system also carries storage water for domestic use. There are 50.8 miles of canal in this system. The canal needs include; diversions, measuring units, sluices, checks, canal lining (high seepage areas) and other structures.

The onfarm needs include; measuring units, ditch lining, farm pipeline, land leveling, irrigation water management, and irrigation method changes.

01-05 BERGEN DITCH - is located in Jefferson County, Colorado. It serves 307 acres of irrigated cropland and pastureland southwest of Denver, Colorado. The water sources is a diversion on Turkey Creek south of Morrison, Colorado. It carries direct diversions along with water for storage. Bergen Ditch has 8.23 miles of canal with 4 reservoirs. The needs of the canal include canal lining, measuring units, turnouts, culverts, also two reservoirs are in need of repair.

The onfarm needs include ditch lining, land leveling, irrigation water management, and a change in irrigation methods.

01-06 PELLA (has been combined with 01-07)

01-07 CLOVER BASIN, PECK, AND PELLA DITCHES - are located in Boulder County, southwest of Longmont, Colorado. These ditches serve 2,345 acres of irrigated cropland on the south side of St. Vrain Creek. The water source is a diversion on St. Vrain Creek west of Longmont, Colorado. The system also carries storage water. These are 9 miles of canal in this system. The canal needs include turnouts, checks, flumes, canal lining, and other structures.

The onfarm needs include water-control structures, ditch lining, and irrigation management.

01-08 GODDING DITCH - is located in Weld County, southeast of Longmont, Colorado. The ditch serves 2,884 acres of irrigated cropland. The water source is from Idaho Creek, which comes from Boulder Creek. There are 5.7 miles of ditch east of Idaho Creek. The needs of the canal include canal lining (because of the high seepage losses, gravel area) and other needed structures.

The onfarm needs include water-control structures, ditch lining, and irrigation water management.

01-09 GREELEY AND LOVELAND CANAL - has its headgate located in Larimer County on the Big Thompson at Loveland, Colorado. The canal goes into Weld County where most of the irrigated cropland served by this canal is located. It carries direct diversions along with water for storage. The canal is 35 miles in length and serves 17,000 acres in both Larimer and Weld Counties. One of the storage reservoirs needs some repair work done on it. This system also has reservoirs located above the point of diversion on the Big Thompson. Canal needs include bridges, cleaning, canal lining and pipelines.

The onfarm needs include water-control structures, ditch lining, farm pipeline, land leveling, irrigation water management, and irrigation method changes.

01-10 LARIMER COUNTY CANAL - is located in Larimer and Weld Counties. It serves 49,892 acres of irrigated cropland in these counties. The water source is northwest of Ft. Collins on the Cache La Poudre River. It carries direct diversions along with water for storage in 11 reservoirs. The canal length is approximately 66 miles. The needs of the canal system includes minor improvement on ten reservoirs, canal lining and cleaning.

The onfarm needs include water-control structures, ditch lining, farm pipeline, land leveling, irrigation water management, and change in irrigation methods.

01-11 DRY CREEK AND 01-12 BARNES DITCH - These ditches have been included in with 01-09 Greeley and Loveland Canal.

01-13 JAMES DITCH - is located in Boulder County, Colorado. It serves 1,200 acres or irrigated cropland on the south side of St. Vrain Creek at Longmont, Colorado. The water source is a diversion on St. Vrain Creek at Lyons, Colorado. It carries water for storage along with direct diversions. There are 11.8 miles of canal in this system. The canal needs include turnouts, checks, flumes, and canal lining.

The onfarm needs include water-control structures, ditch lining, farm pipeline, and irrigation water management.

01-14 BRIGHTON DITCH - is located in Adams County, Colorado. It serves 1843 acres of irrigated cropland west and northwest of Brighton, Colorado. The water source is a diversion on the South Platte River, southwest of Brighton. The canal needs include repair on diversion, canal lining, and realignment. The onfarm needs include water-control structures, ditch lining, irrigation water management, and change in irrigation method.

02-01 JOHNSON AND EDWARDS DITCH - is located in Washington County, Colorado. It serves 1,675 acres of land on the south side of the South Platte River, between the South Platte River and Prewitt Reservoir. The canal is 3.5 miles in length with the water source being the South Platte River and the Prewitt Inlet Ditch being the carrier from the river to its headgate. The canal needs include a measuring unit and canal lining.

The onfarm needs include water-control structures, ditch lining, farm pipeline, irrigation water management and irrigation scheduling.

02-02 TETSEL DITCH - is located in Morgan and Washington Counties, Colorado. It serves 1,275 acres of irrigated cropland on the north side of the South Platte River, southwest of Merino, Colorado. The water source is a diversion on the South Platte River in Morgan County. There are 6.5 miles of canal in this system. The canal needs include a diversion, measuring units, sluice, turnouts, and canal lining.

The onfarm needs include farm pipeline, land leveling, irrigation water management, and a change in irrigation method.

02-03 BIJOU CANAL - is located in Weld and Morgan Counties, Colorado. It serves approximately 25,000 acres of irrigated cropland in these counties. The water sources are 1) diversion on the South Platte River east of Hardin, which gives direct flows, 2) releases from Empire Reservoir, and 3) exchange water. The Bijou Canal has approximately 128 miles of transmission ditches with the two reservoirs. The canal needs include turnouts, checks, flume, canal lining, and cleaning. The onfarm needs include water-control structures, ditch lining, farm pipelines, land leveling, irrigation water management, and change in irrigation methods.

02-04 RIVERSIDE CANAL - is located in Weld and Morgan Counties, Colorado. It serves 21,000 acres of irrigated cropland on the north side of the South Platte River. The diversion is located in Weld County east of Kersey, Colorado, on the South Platte River. The Riverside Inlet carries water to the Riverside Reservoir to be used as needed by the water users. The needs on the 104 mile canal system include turnouts, checks, flumes, wasteway, cleaning and canal lining of high seepage areas.

The onfarm needs include water-control structures, ditch lining, farm pipeline, land leveling, irrigation water management, and change in irrigation method.

02-05 TREMONT SNYDER CANAL - is located in Morgan County, Colorado. It serves 4,500 acres of irrigated cropland on the northside of the South Platte River, north of Brush, Colorado. The water source is a diversion on the South Platte River between Brush and Fort Morgan. The canal is 14 miles in length. The canal needs include measuring units, sluice, turnouts, checks, flume, culverts, canal lining, cleaning, enlargement, and other structures.

The onfarm needs include water-control structures, ditch lining, farm pipeline, land leveling, irrigation water management, and a change in irrigation method.

02-06 SOUTH PLATTE CANAL - is located in Washington and Logan Counties, Colorado. It serves 2,049 acres of irrigated cropland on the south side of the South Platte River. The water source is a diversion on the South Platte west of Prewitt Reservoir. The canal is approximately 12 miles in length. The canal needs include a diversion, measuring units, sluice, checks, flumers and canal lining.

The onfarm needs include water-control structures, ditch lining, farm pipelines, and irrigation water management.

02-07 SPRINGDALE DITCH - is located in Logan County, Colorado. It serves 3,900 acres of irrigated cropland on the north side of the Platte River at Sterling, Colorado. The water source is a diversion on the South Platte River south of Atwood, Colorado. The canal is 17 miles in length and has needs which include a diversion, measuring units, a sluice, turnouts, checks, flumes, culverts, canal lining, cleaning, and other structures.

The onfarm needs include water-control structures, ditch lining, farm pipelines, land leveling, and irrigation water management.

02-08 NORTH STERLING CANAL - is located in Morgan, Washington, and Logan Counties, Colorado. It serves 40,926 acres of irrigated cropland on the north side of the South Platte River. The water source is a diversion on the South Platte River north of Hillrose in Morgan County. The water is delivered to North Sterling Reservoir by the North Sterling Inlet Canal. The total length of the canal plus laterals is 178 miles. The canal needs include a new diversion and canal lining.

The onfarm needs include water-control structures, ditch lining, farm pipeline, land leveling, irrigation water management, and change in irrigation method.

02-09 FARMERS PAWNEE CANAL - is located in Logan County, Colorado. It serves 10,000 acres of irrigated cropland on the north side of the South Platte River, near Sterling, Colorado. The water source is a diversion on the South Platte River southwest of Merino, Colorado. The canal is approximately 28 miles long with needs for a diversion, measuring units, a sluice, turnouts, checks, flumes, culverts, canal lining, canal pipelines, cleaning, and other structures.

The onfarm needs include water-control structures, ditch lining, farm pipeline and irrigation water management.

03-01 JULESBURG IRRIGATION DISTRICT - is located in Logan and Sedgwick Counties, Colorado. It serves 26,560 acres of irrigated cropland on the north side of the South Platte River between Sterling and Julesburg, Colorado. The water source is a diversion on the South Platte River.

Harmony Ditch delivers water to Julesburg Reservoir, which in turn supplies water to Highland Canal, Settlers Ditch, and Peterson Ditch. There are approximately 103 miles of conveyance canals and ditches that serve 156 farmers in this system. The needs of these canals include water-control structures, canal lining, and canal pipeline.

The onfarm needs include ditch lining, farm pipeline, water-control structures, irrigation water management, and land leveling.

03-02 PIONEER DITCH - is located in Yuma County, Colorado, with the lower portion being in Nebraska. It serves 2,690 acres of irrigated cropland on the south side of the Republican River at Laird, Colorado. The water source is a diversion on the Republican River. There are approximately 17.5 miles of canal that serves 26 farms in this system. The needs of the canal include an off channel storage reservoir, canal lining, upgrade diversion, and water-control structures.

The onfarm needs include ditch lining, farm pipeline, water-control structures, irrigation water management, and a change to sprinklers.

03-03 LAIRD CANAL - is located in Yuma County, Colorado. It serves 251 acres of irrigated cropland on the north side of the Republican River at Laird, Colorado. The water source is a diversion on the Republican River. There are approximately 5 miles of canal that serves 8 farms in the system. The needs of the canal include canal lining and water-control structures.

The onfarm needs include ditch lining, farm pipeline, water-control structures, irrigation water management, and a change in irrigation method.

Tables B and C give additional information on these 23 irrigation systems.

TABLE B. SUMMARY OF CHARACTERISTICS OF THE 23 IRRIGATION SYSTEMS EVALUATED

MISSOURI RIVER BASIN, COLORADO

	Company	Irrigation Acres	Miles Ditch	# Res.	Water Shortage %	System Efficiency %
1-1	Highland	35,000	21	6	68%	34%
1-2	R&R	500	16.4		18%	30%
1-3	Palmerton	60	5.5		0	33%
1-4	Left Hand	13,342	50.8		65%	29%
1-5	Bergen	307	8.2	4	84%	17%
1-6	Pella Combined with (1-7)					
1-7	Clover Basin	2,345	9		69%	29%
1-8	Gooding	2,884	5.7		51%	27%
1-9	Greeley-Loveland	17,000	35	2	10%	34%
1-10	Larimer County	49,892	66	11	51%	34%
1-11	Dry Creek	Combined with (1-9)				
1-12	Barnes Ditch	Combined with (1-9)				
1-13	James Ditch	1,200	11.8		61%	29%
1-14	Brighton	1,843	7.0		18%	32%
Subtotal		124,373	236.4			
2-1	Johnson & Edwards	1,675	3.5		6%	26%
2-2	Tetsel	1,275	6.5		55%	20%
2-3	Bijou	25,000	128	3	42%	23%
2-4	Riverside	21,000	104	1	3%	22%
2-5	Tremont-Snyder	4,500	14		8%	22%
2-6	So. Platte	2,049	12		6%	25%
2-7	Springdale	3,900	17		14%	29%
2-8	No. Sterling	40,926	178	1	64%	24%
2-9	Farmers Pawnee	10,000	28		26%	25%
Subtotal		110,325	491			
3-1	Julesburg	26,560	103	1	49%	27%
3-2	Pioneer	2,690	17.5	1	58%	21%
3-2	Laird	251	5		0	23%
Total (26) Subtotal		29,501	125.5			
	TOTAL	(264,199)	(852.9)			

TABLE C IDENTIFIED NEEDS IN THE 23 SYSTEMS STUDIED
MISSOURI RIVER BASIN, COLORADO

System Name	Total Irrigated Area (Acres)	Present Full Water Supply (Acres)	Conveyance Systems Needs: Canal Lining (Miles)	Canal Pipe (Miles)	Div. Str (No.)	Control Str. (No.)	Res. Impr. (No.)	On-farm Practice Needs: Ditch Lining (Miles)	Irr. Pipe (Miles)	Control Str. (No.)	Land Level (Acres)	IWM (Acres)	Conv Irr Method (Acres)	Cons Crop Systems (Acres)
Highland	35000	8749				4	1	20	13	150	700	35000	3000	
Rough & Ready	500	440				24		3		13		500		
Palmerton	60	60				4			1	2		60		
Left Hand	13342	4302	5.00		3	163	1	90	50	120	1500	13342		1500
Bergen	307	80	3.43			16	1				150	307		
Clover Basin	2345	603	2.00			65		4		40		2345		
Godding	2884	1496	5.30			34		13		22		2884		
Greeley-Loveland	17000	17000		7.5		2	1	7		14	2000	17000		2000
Larimer County	49892	23202	4.00			3		20	5	100	1000	49892		3000
James	1200	440	2.00			51		2	1	25		1200		
Brighton	1843	1740	0.40		1	1		5		12	500	1843	400	
Johnson-Edwards	1675	1590	3.50			27		5		1		1675		
Tetsell	1275	546	5.60		1	16			1		200	1275	200	
Bijou	25000	12479	4.00			5		39	20	120	3000	25000	3000	
Riverside	21000	21000				123		10	8	240	2000	21000	2000	
Tremont-Snyder	4500	4248	6.00			79		4	8	30	400	4500	400	
South Platte	2049	2049	4.00		1	34		3	1	11		2049		
Springdale	3900	3290	4.00		1	66		4	2	10	100	3900	100	
North Sterling	40926	2127	14.00		1			30	20	160	3000	40926	2000	
Farmers Pawnee	10000	6481	6.00	1.0	1	123		4	5	25		10000		
Laird	251	251	4.00			6		4	4	20		251	160	
Pioneer	2690	1026	15.70		1	28	1	13	15	80		2690	640	
Julesburg	26560	5300	20.00	1.5		128	1	30	15	80	3000	26560	1600	
TOTALS	264199	118515	109.01	10.0	10	1002	6	310	169	1275	17550	264199	13500	6500

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Alternatives

Using the data from the worksheets for these canal systems,alternative plans were developed for each system. The alternative plans for canals and onfarm improvements were composed of various combinations and amounts of the following elements: canal lining, canal pipelines, diversion structures, water-control structures, reservoir modifications, onfarm ditch linings, onfarm pipelines, land leveling, changes in irrigation methods and irrigation water management. Plans ranging from primarily management only to total needed structural and management treatment, were considered. Each alternative plan was evaluated to determine its impacts on water supplies - both surface and ground-water quality, change in land use or cropping patterns and yields, change in production costs, and change in operation, maintenance and replacement costs. The computer program, Irrigation Project Evaluation System (IPES), was developed to evaluate and compare the economic effect of each alternative with their yearly benefits. (See Appendix I for an example)

The alternatives for possible consideration on each system are listed as follows:

FWOP - Future without project.

FWOP #2 - Future without project with limited changes in cropping patterns allowed - no more than a 40 percent reduction and/or 10 percent increase in acres of any crop.

Alternative #1 - Irrigation Water Management

Alternative #2 - "Canal Company Alternative" - Irrigation Water Management along with structural measures to meet onfarm needs, and measures to satisfy canal company stated needs in conveyance system.

Alternative #2M - Same as alternative #2 except the conveyance system lining lengths were modified to match the high seepage portions of the canal.

Alternative #3 - Off-farm (canal) conveyance system structural needs. (Irrigation Water Management not included)

Alternative #4 - Onfarm structural needs. (Irrigation Water Management not included)

Table D displays the most economically feasible alternative found in each of the 23 systems studied.

TABLE D ECONOMICALLY FEASIBLE ALTERNATIVES IN THE 23 SYSTEMS STUDIED
MISSOURI RIVER BASIN, COLORADO

System Name	Most Feasible Alt.	Total Irrigated Area (Acres)	Present Full Water Supply (Acres)	Conveyance Systems Needs: Canal Lining (Miles)	Canal Pipe (Miles)	Div. Str (No.)	Control Str. (No.)	Res. Impr. (No.)	On-farm Practice Needs: Ditch Lining (Miles)	Irr. Pipe (Miles)	Control Str. (No.)	Land Level (Acres)	IWM (Acres)	Conv Irr Method (Acres)	Cons Crop Systems (Acres)	Total Install. Cost ($)	Annual Cost + O&MR ($)	Annual Net Benefits ($)
Highland	#2M	35000	15009	4.20			4	1	20	13	150	700	35000	3000		8255953	872486	44629
Rough & Ready	IWM	500	434										500			40643	3930	818
Palmerton	IWM	60	56										60			4877	472	80
Left Hand	IWM	13342	4797										13342			1084511	104870	6509
Bergen	IWM	307	88										307			24955	2413	140
Clover Basin	#4+IWM	2345	857						4		40		2345			568942	60791	1410
Godding	IWM	2884	1652										2884			234427	22669	3042
Greeley-Loveland	IWM	17000	17000										17000			1381854	133622	22860
Larimer County	#2	49892	26281	4.00			3		20	5	100	1000	49892		3000	8896549	931053	35551
James	IWM	1200	479										1200			97543	9432	1427
Brighton	#2	1843	1843	0.40		1	1		5		12	500	1843	400		1087093	120459	-2273
Johnson-Edwards	IWM	1675	1624										1675			136153	13166	1647
Tetsell	IWM	1275	604										1275			103639	10022	1459
Bijou	#2	25000	18408	4.00			5		39	20	120	3000	25000	3000		10808954	1166676	131
Riverside	IWM	21000	21000										21000			1706996	165062	36316
Tremont-Snyder	IWM	4500	4391										4500			365785	35370	7750
South Platte	IWM	2049	2049										2049			166554	16105	3029
Springdale	IWM	3900	3588										3900			317013	30654	6399
North Sterling	#2	40926	15479	14.00		1		1	30	20	160	3000	40926	2000		19081641	2048192	-49399
Farmers Pawnee	IWM	10000	7942						4	5	25		10000			1540298	156919	21296
Laird	IWM	251	251										251			20403	1973	475
Pioneer	IWM	2690	1153										2690			218658	21144	3583
Julesburg	IWM	26560	4400										26560			2158943	208764	37596
TOTALS		264199	149385	26.60	0.0	2	13	2	122	63	607	8200	264199	8400	3000	58302384	6136244	184482

The two systems with negative net benefits were included because it was felt that addition studies would uncover enough additional benefits to make the projects viable.

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Results of System Analysis

Alternative #1 - Irrigation Water Management was found to be economically feasible in all of the systems studied. Alternative #2 - Canal Company Alternative was found to be economically feasible in the Larimer County, Brighton, Bijou and North Sterling systems. This alternative was also economically feasible in the Highland systems; however, Alternative #2M - Canal Company Alternative Modified produced higher net benefits. Alternative #4 Onfarm Structure Needs was found to be economically feasible in the Clover Basin and Farmers Pawnee systems.

Table E summarizes the system improvements found to be economically feasible and compares this with the system improvements believed to be needed, shown on Table A.

Table E Economically Feasible Improvements and Remaining Needs for 23 Sample Irrigation Systems 1/
Missouri River Basin, Colorado

Item	Unit	Identified Need	Feasible Improvements	Remaining Needs
Canal				
Reservoir Imp.	No.	6	2	4
Lining	Miles	109	26.6	82.4
Pipeline	Miles	10	0	10
Diversion Str.	No.	10	2	8
Water Control Str.	No.	1,002	13	989
Onfarm				
Ditch Lining	Miles	310	122	188
Pipeline	Miles	169	63	106
Water Cont. Str.	No.	1,275	607	668
Land Leveling	Ac.	17,550	8,200	9,350
Irr. Water Mgt. 2/	Ac.	264,199	264,199	0
Convert Irr. Method 3/	Ac.	13,500	8,400	5,100
Cons. Crop System 4/	Ac.	6,500	3,000	3,500

1/ Sample of 25 percent of predominantly surface water supplied systems.
2/ This is a non-structural practice involving improvements such as: irrigation scheduling, time of irrigation set, optimum stream size, tailwater management.
3/ Change from surface systems to sprinkler systems.
4/ Non-Structural practices of management of crop residue.

Over 58 million dollars will be needed to construct the improvements found to be economically feasible in the systems studied. However, if all of these improvements are installed a full water supply can be given to 149,000 acres. This represents an increase of about 30,000 acres from the present. The remaining irrigated lands under these systems will have additional water available, but not enough to satisfy all the crop needs.

Details about each system studied along with copies of the model outputs can be found in the Irrigation System Report (WIR's) published separately for each system. (An example is shown in Appendix J)

BASIN CONCLUSIONS

Introduction

Over 1,580,000 acres are irrigated within the study area. Of this area 938,000 acres are located in the South Platte River Basin, 105,000 acres in the North Platte River Basin and the remaining 537,000 acres located in the Republican River Basin. Generally the area in both the North and South Platte River Basins are irrigated predominantly by surface water while the area in the Republican River Basin is irrigated predominantly by ground water.

The 23 ditch systems studied supply water to over 264,000 acres. This area represents about 25 percent of all the land irrigated with surface water supplies and provides a good sample that represents the problems and needs found in all the systems located downstream of Denver in the South Platte River Basin. The sample does not represent high elevation systems, such as those located in the North Platte River Basin or lands irrigated exclusively with ground water.

Delivery System Needs and Potentials

About 40 percent of the irrigation systems managers reported that a new diversion structure is needed or major repairs are needed to their existing diversion structure. This study showed that about 20 percent of the needed work can be economically justified.

All of the system managers reported that some canal lining would improve their system. Water control structures should be replaced when the lining is installed. The study showed that about 24 percent of this work can be justified.

Generally the lining of high seepage reaches of canals will pay when the system is very water short. As this is a very high construction cost item, it can be justified in severe areas only. Reservoir improvements were identified in 26 percent of the systems studied. Justification of these improvements using water saving alone is difficult. The study did not address dam safety issues.

Onfarm Needs and Potentials

Onfarm ditch lining or pipelines were recognized as needed in all but one system of those studied. Approximately 39 percent of the lining that is needed can be justified based upon water losses. Other benefits such as labor saved or convenience to the irrigator were not addressed in this study.

As with ditch lining, onfarm water control structures were identified as needed in all but one system. About 48 percent of the structures identified as needing work can be economically justified.

Additional land leveling needs were identified on over 6 percent of the area studied. About one half of this work will produce net benefits when evaluated alone. This practice is needed to obtain proper irrigation water management. The study showed that all of the irrigated lands needed and produced positive net benefits when proper irrigated water management is applied.

Local leaders reported that about five percent of the irrigated land should be converted to sprinkler irrigation methods. Over 62 percent of the conversion can be justified using the saving in water and resulting crop production increases. Furrow irrigation efficiency can be improved by using surge irrigation or cablegation. These methods will save water and increase crop production.

Water Use

Water shortages were identified in 21 out of the 23 systems studied. Presently about 45 percent of the irrigated lands receive a full water supply. If all of the improvements found economically feasible were installed, a full water supply could be supplied to over 56 percent of the area. This amount of improvement in the full water supply could be expected throughout the basin when projects are installed.

Appendix C gives a general accounting of water supply and use within the basin.

A Soil Conservation Service computer model is available that can relate a forecast water supply to irrigated crop water requirements in a water balance type analysis. This could be useful in making crop planting decisions.

Detailed land treatment including water conservation (IWM), and/or structural irrigation measures can be developed through programs such as PL 566. Cost sharing may also be available. However, under present USDA policy, irrigation projects receive a low funding priority. The chapter on implementation explains USDA and non-USDA programs in more detail.

Future Project Studies

The conclusions drawn in the discussion above are based upon current crop prices, yields, interest rates, construction costs and other current factors. As these factors change overtime the economic viability of project action will change. These factors will not change the fact that the area is water short. Economically feasible actions to conserve or make better use of the available water supply will help all irrigators throughout the basin.

IMPLEMENTATION

Introduction

This chapter outlines the federal, state and local programs which may be used to assist with implementation of various alternative treatment measures. Specific request for assistance must be made before any of the alternative measures can be implemented on private lands.

USDA PROGRAMS

Forest Service

Multiple Use - Sustained Yield Act

This Act provides for the management and development of the recreation resource on national forests. Forest Service recreation programs are coordinated with the private sector and other government agencies to avoid duplication of effort.

Forest resources on national forest lands are managed to conserve the land and its natural vegetation while providing feed for livestock and wildlife. Under the multiple use management concept, grazing lands are also required to be managed for their watershed, wildlife and recreation values. Programs for rehabilitating poor condition range lands to increase forage production are an important part of the Forest Service range programs.

The Act also makes provisions for timber management and includes the various management practices designed to improve the vigor, stocking, composition, productivity and quality of forest stands.

Small Watershed Program - Public Law 83-566

In cooperation with other USDA Agencies, this program involves planning and implementing measures for the protection, conservation and improvement of land and water resources. Through national forest management and cooperative programs with state and local governments, and private landowners, the Forest Service participates in the protection, management and use of forest and associated watershed lands. Through Public Law 566 assistance is provided for gully stabilization, erosion control, rehabilitation of abandoned roads and trails, restoration of mined areas, and full development of multiple use on state and private lands.

Cooperative Forestry Assistance Act of 1978 - Public Law 95-313

Under this program the Forest Service is authorized to work through and in cooperation with State Foresters and equivalent State officials in implementing Federal programs affecting nonfederal forest land by providing assistance in (1) the advancement of forest resource management; (2) the encouragement of the production of timber; (3) the prevention and control of insects and diseases affecting trees and forests; (4) the prevention and control of rural fires; (5) the efficient utilization of wood and wood residues, including the recycling of wood fiber; (6) the planning and conduct of urban forestry programs; (7) the improvement and maintenance of fish and wildlife habitat; and (8) the enhancement of the soil and water resources.

This program complements the policies and directions set forth in the Forest and Rangeland Renewable Resource Planning Act of 1974.

Soil Conservation Service

Assistance to Soil Conservation Districts - Public Law 46

Under the authorities of this program, the Soil Conservation Service through local conservation districts assists both individuals and groups in the planning and application of needed soil and water conservation on private lands. This Act can provide technical assistance to landowners for conserving land and water resources in the Basin in the national interest.

Small Watershed Program - Public Law 83-566

Under the authorities of this program, USDA agencies provide assistance to sponsoring local organizations in planning and carrying out a program for the development, use and conservation of the soil and water resources of a small watershed area. This includes treatment and protection of federally owned land within such watershed areas.

Great Plains Conservation Program

USDA assistance under this program is designed to accelerate the application of needed conservation practices to conserve land and water resources on private land. The program can provide cost-sharing to help offset the cost to landowners in the designated Great Plains counties. All the counties in the Basin, except for Denver, Jackson, Gilpin and Clear Creek Counties, are designated as Great Plains counties.

Resource Conservation and Development Program

The Resource Conservation and Development Program (RC&D), administered by the Soil Conservation Service, is designed to expand the economic opportunity for people in approved planning areas. Under the program, USDA agencies provide technical, cost-sharing and loan assistance to local sponsors by developing and carrying out action plans for conservation improvement, development and wise use of natural resources. The East Central Colorado RC&D area is located within part of the Missouri River Basin.

Cooperative Snow Surveys

Snow surveys conducted by the SCS provide a means of water supply forecasting. More effective utilization of water is possible by having advance knowledge of seasonal and annual water supplies. Snow surveys have been conducted within the basin since 1930. Regular forecasts are made monthly during the winter and spring and a "Forecast of the Water Supply Outlook" is published by the SCS. These are distributed to all water users, water resource agencies, and others who utilize these data. Appreciable assistance is provided by other Federal and State agencies as well as private corporations and individuals.

Assistance can be provided to irrigation ditch companies to develop and apply water management plans based on relating SCS streamflow forecasts to their anticipated water deliveries for the irrigation season. The companies can then project anticipated water deliveries to individual farms where the landowner can make rational choices between cropping alternatives.

Ogallala Targeted Area

A six state study authorized by Congress has been completed. The study investigated the extent of groundwater depletion of the Ogallala Aquifer, its impacts on the High Plains Area, and made recommendations for action. The Economic Development Administration of the Department of Commerce managed the project. The Colorado portion was conducted by Colorado State University, Colorado Division of Water Resources, Colorado Department of Local Affairs, and Colorado Office of Energy Conservation. The Colorado Department of Agriculture coordinated research and public involvement.

The study developed 20 recommendations to address the problems associated with groundwater depletion. Recommendation #13 was for SCS to target assistance into the Ogallala Region. Since 1983, SCS has targeted technical assistance funds to improve IWM and prolong the useful life of the Ogallala Aquifer for the objective of supporting stable agricultural enterprises. The primary purpose is to take actions which will lead to more efficient use of water and energy.

Agricultural Stabilization and Conservation Service

Agricultural Conservation Program (ACP)

The ACP administered by the Agricultural Stabilization and Conservation Service provides funds for cost-sharing with individual and groups of landowners and operators for the installation of conservation practices.

Forestry Incentive Program (FIP)

The Forestry Incentives Program (FIP) provides long-term technical and financial assistance to forest land owners. It is a cost share program with the purpose of providing for road access, forest protection, and timber stand improvement.

Farmers Home Administration

Loan Programs (FmHA)

The Farmers Home Administration is authorized to make loans to various non-federal landholders for the implementation of various land and water development measures. Landholders eligible for these loans are public and quasi-public bodies, nonprofit corporations and private individuals or groups owning land. Loan assistance is available for the development of recreation areas, irrigation and flood prevention facilities, and forestry and land treatment measures. Loans from FmHA may be used to pay the local share of most watershed projects and RC&D measures.

Cooperative Extention Service

The Extension Service serves as liaison between research agencies, educational institutions, local, federal, and state agencies, landowners, and other individuals. It makes information and education materials in improved crop varieties and livestock, land management use and practices, soil testing, and other similar problems relating to livestock, crops, range, farm management, and economics available to all groups of individuals who are interested.

County Agents in the Basin are actively assisting in the identification and solutions of the water and related land resource problems and needs.

Other Programs - Federal Agencies

United States Department of Interior-Bureau of Reclamation

Narrows Unit, Colorado

The proposed project is located along the South Platte River approximately 7 miles west of Fort Morgan, Colorado. The project is anticipated to be a multipurpose development serving the functions of irrigation, flood control, recreation, fish and wildlife enhancement, and improvement of water quality. Storage water would be released as necessary from the reservoir to supplement irrigation downstream on approximately 166,370 acres of the Lower South Platte Water Conservancy District.

Other Programs - State Agencies

Colorado Water Conservation Board

The broad statutory mandate of the Colorado Water Conservation Board is to secure the greatest utilization of the water of the state, to prevent floods, and to protect the rights of the state in interstate streams. In this context, the Board is the state's policymaking and water planning agency in all matters concerning intra- and interstate water development, conservation and management. Furthermore, it has the responsibility of coordinating its functions with other state agencies and with other units of government, both federal and local, and of representing the state in interstate forums.

The Colorado Water Conservation Board is responsible for carrying out programs in seven major areas:

Project planning and construction;
Flood control and floodplain management;
River basin (regional) planning;
Protection of interstate waters and compacts;
Instream flow appropriations;
Colorado River Basin salinity control;
Hydrologic investigations.

Colorado State Conservation Board

The State Soil Conservation Board is charged with the responsibility of fostering the conservation of soil and water resources of the State by disseminating information throughout the state concerning the activities and programs of Soil Conservation Districts and promoting and assisting in the organization of Soil Conservation Districts. The Board is charged with the allocation of state funds used for financial assistance to the Soil Conservation Districts.

The Board receives watershed protection and flood prevention applications and determines feasibility for them. The Board may act as the state contracting agency. It may also serve in the same capacity for resource conservation and development projects within the state.

The Board is also charged with coordinating the programs for soil conservation districts within the state through the supervisors of local district boards. The Board also acts as liaison between local soil conservation districts and a number of federal agencies on problems pertaining to local districts and member landholders.

Colorado Division of Water Resources-State Engineer

This Division is responsible for the administration of the water supply of the state. The state statutes mandate that this division shall ensure that the state waters are preserved for the use and benefit of the citizens and inhabitants of the state for its growth, property and general welfare.

The Division of Water Resources is responsible for carrying out the following activities:

a. Operations of the Information Service program. This involves the collection, storage, and dissemination of water rights data and results of technical investigations and provides information to the general public.

b. Statewide regulation, analysis and coordination of groundwater use and supply in the state.

c. Evaluation of Colorado's surface water. This includes:
   (1) Evaluation and approval of plans for new dams and inspection of existing dams to maintain adequate safety standards.
   (2) Coordination of the actual measurement of surface water supplies.
   (3) Evaluation and approval of requests for surface water supplies by subdivisions, industries, etc.
   (4) Collection, storage, and evaluation of data on the amount of water available in the state.
   (5) Provides geo-technical support within the Division and to other state agencies.

Colorado Geological Survey

The survey is engaged in continuous programs in four major activites including:

a. Inventory and evaluate the mineral fuel resources (coal, methane, oil, gas, and oil shale) in the state and provide advice to state and local officials on matters relating to these resources.

b. Inventory, map, evaluate and promote the development of the state's mineral resources other than mineral fuels.

c. Study the availability of groundwater and geothermal resources.

d. Conduct project reviews on land use, subdivision proposals, and assist local governments in the identification and mitigation of geologic hazard areas.

Colorado Division of Parks and Outdoor Recreation

This Division is involved in continuous activities to protect, preserve, enhance and manage tha natural, scenic, scientific and outdoor recreation areas for the use, benefit and enjoyment of the people. Specifically, the Division is responsible for:

a. Providing a comprehensive outdoor recreation program of planning, acquisition, and development of park areas.

b. Operate and manage existing parks and recreation areas.

c. Administer the Federal Land and Water Conservation Fund.

Two significant recreation areas in the Missouri Tributaries River Basin are administered by the Division, and are associated with Chatfield and Cherry Creek reservoirs.

Colorado Division of Wildlife

This Division is responsible for the protection, preservation, enhancement and management of wildlife and their environment. Three major programs are implemented, on a continous basis, to accomplish these objectives:

a. Maintenance of wildlife population numbers and providing hunting opportunities.

b. Maintenance of fish population and providing fishing opportunities.

c. Administers the Non-Game Wildlife Progam.

Specific programs underway in the Missouri Tributaries.

a. Research on annual production and distribution of sport fish.

b. Operation fish hatcheries and rearing facilities.

c. Lake habitat improvement.

d. Fisheries inventory and development - numberous streams and reservoirs.

e. Evaluation of sport fisheries potential in fluctuating plains streams and reservoirs.

f. Non-game habitat improvement investigations.

g. Improvement of wildlife habitat on public and private lands.

h. Stream improvement on private lands.

i. Administration of state wildlife management areas.

Colorado Division of Water Quality Control-Water Quality Control Commission

The Division is responsible for the development and maintenance of a comprehensive and effective program for the prevention, control, and abatement of water pollution for water quality protection. In connection with this function, the Division shall classify the waters of the state, promulgate water quality standards, control regulations, and waste discharge permit regulations, enter into contracts with municipalities and individuals with respect to the location, construction, financing, and operation of sewage treatment plants. Administration of these programs is accomplished by the Division of Water Quality Control.

Northern Colorado Water Conservancy District

The Northern Colorado Water Conservancy District operates certain features of the Colorado-Big Thompson Project. This project supplies supplemental irrigation water to much of the western South Platte Basin. In addition the District is continuing to perform and sponsor studies to identify approaches for conserving, developing, and efficiently utilizing regional water resources for irrigaiton, hydroelectric power generation, recreation, municipal and industrial uses, and fish and wildlife uses.

APPENDIX A

CLIMATE

Precipitation

An important feature of precipitation in the plains of Colorado is the large proportion of the annual total which falls in the growing season - 70 to 80 percent during the period from April through September. Summer precipitation in the plains is largely from thunderstorm activity and is sometimes extremely heavy. Precipitation decreases gradually from the eastern border to a minimum near the mountains and then increases rapidly with increasing elevation of the foothills. Most precipitation in the higher mountains occurs in the winter months. Summer rainstorms do not have the intensity or duration of those in the plains or front range foothills. The mountain snow pack provides spring runoff and summer base flow to streams serving those irrigated croplands concerned with in this study.

Figure A-1 gives a seasonal distribution of precipitation, and Table A-1 gives normal annual values at selected locations. Figure A-2 shows average snow depths and water equivalent at a selected snow course in the mountains. Figure A-3 is a general mean annual precipitation map of the basin.

Temperature and Growing Season

Most of Colorado has a cool and invigorating climate which could be termed a highland or mountain climate of a continental location.

Summer daily maximum temperatures are often 95°F or above in the plains below 5,000 ft. elevation. The usual winter extremes are from zero to 10°F below zero. At the western edge of the plains, near the foothills, there are a number of significant changes in climate as compared to the plains. Areas near the mountains have less average wind movement but have severe turbulent winds. Temperature changes from day to day are not as great, however summer temperatures are lower and winter temperatures higher.

Northeastern Colorado has a growing season averaging 140 days, which is suitable for crops such as wheat, spring grains, corn, alfalfa, and sugar beets. The mean date of first 32°F temperature in spring varies from about May 10 in the plains to May 30 along the front range foothills. The mean date of first 32°F temperature in Autumn varies from about September 30 in the plains to August 30 along the front range foothills.

The mean temperatures and frost dates for selected locations are shown in Table A-2.

Table A-1 Normal Annual Precipitation

Location	Normal Annual Precipitation 1/ Inches
Julesburg	17.44
Fort Morgan	13.20
Longmont	12.74
Denver WSO	12.95
Cheeseman	15.48
Higher Mountains	Up to 40

1/ 1941-70 case period

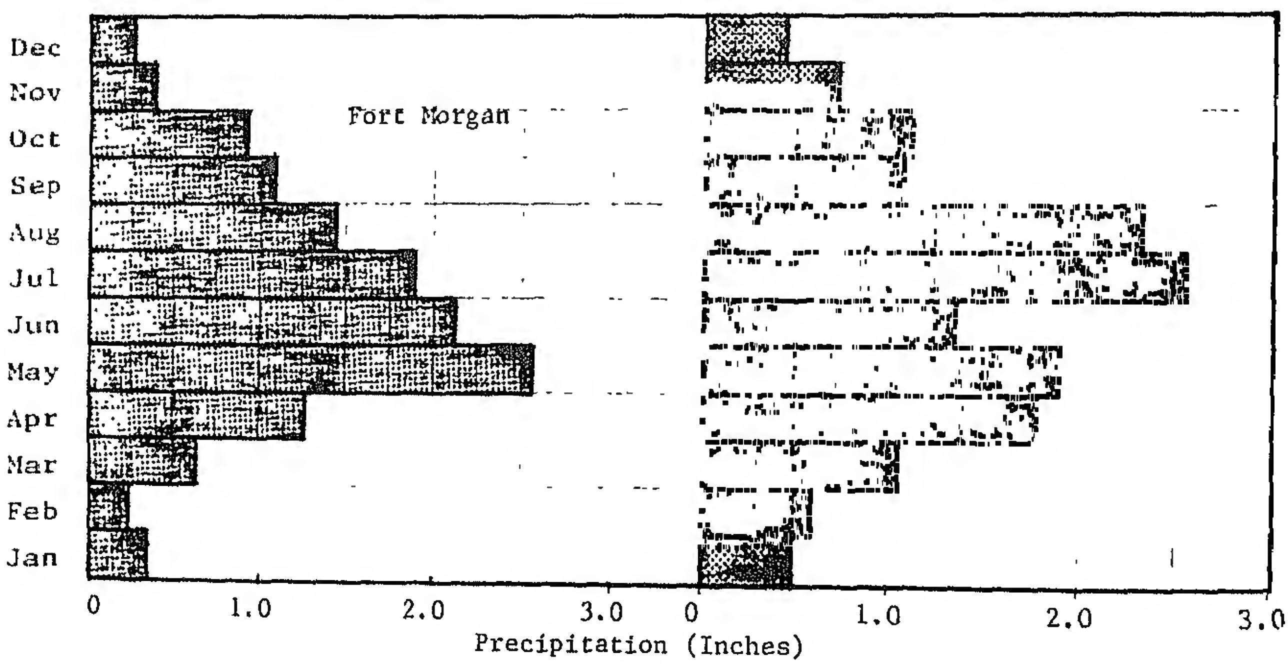


Figure A-1 Monthly Precipitation for Selected Locations

Table A-2 Mean Temperature and Frost Dates

(Degrees F)

Month	Julesburg	Ft. Morgan	Longmont	Denver
January	27.7	24.3	26.8	29.9
February	32.4	29.8	31.0	32.8
March	37.4	36.0	35.9	37.0
April	49.8	48.2	47.1	47.5
May	59.5	58.0	56.6	57.0
June	68.9	67.5	65.0	66.0
July	76.1	74.0	71.6	73.0
August	74.5	71.9	69.9	71.6
September	64.4	62.2	61.0	62.8
October	52.9	51.0	50.4	52.0
November	39.1	36.7	37.4	39.4
December	30.5	28.2	30.3	32.6
Annual	51.1	49.0	48.6	50.1
		Spring Frost Date		
32° Frost	May 7	May 7	May 9	May 5
		Fall Frost Date		
32° Frost	October 4	October 5	September 30	October 12

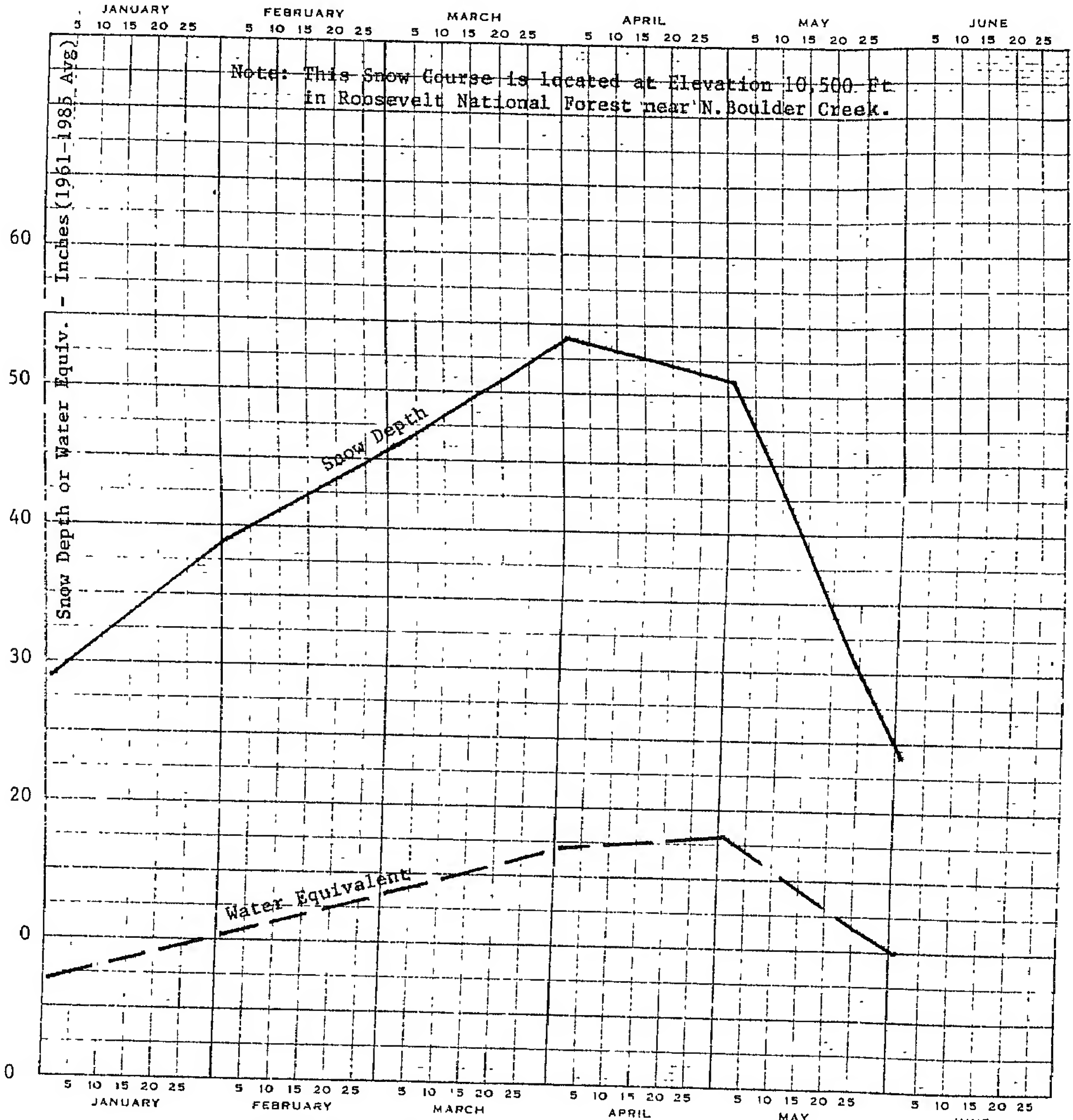
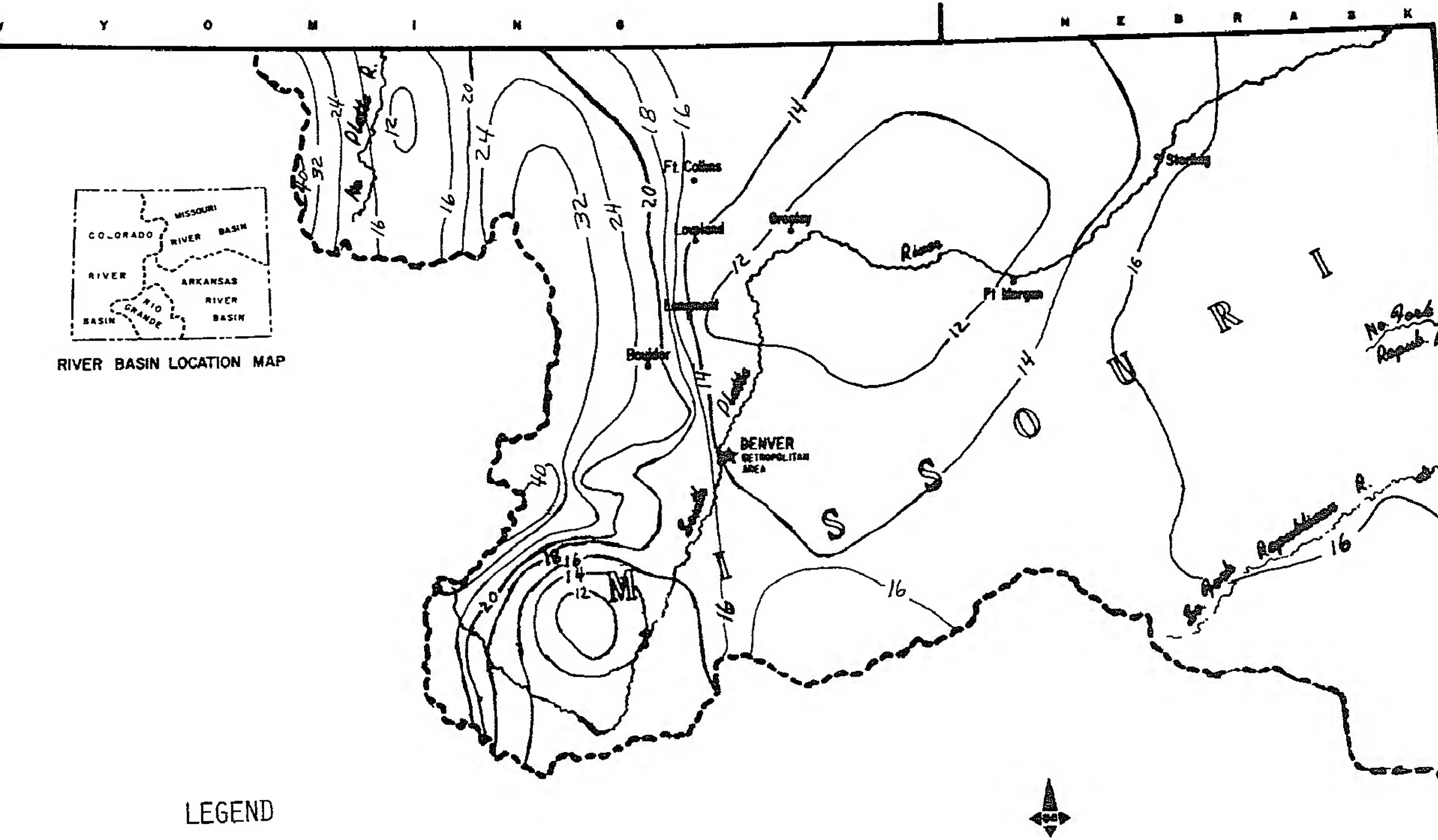


Figure A-2 Snow Data for University Camp Snow Course



LEGEND

ISOHYETAL CONTOURS ——— 12 ———

(IN INCHES)

Figure A-3

MEAN ANNUAL PRECIPITATION

MISSOURI RIVER TRIBUTARIES
COLORADO

APPENDIX B

Soils

The general soil map locates soil with similar characteristics and suitability within the basin, (see soils map and legend). Broad characteristics and relationships can then be used to interpret the potential of soils for agricultural, wildlife, recreational, commercial and industrial uses. Problems of erosion, sediment yield, land use and future development are interrelated with soils and their distribution.

The General Soils Map was prepared by delineating mapping units that differ from each other in the kinds of soils that are present. Soils in each mapping unit form patterns that are repeated from place to place.

Mapping units were defined and described according to requirements imposed by the map scale and criteria from "Soil Taxonomy" published December 1975. The soil map unit numbers in this report correspond to the soil map unit numbers of "Soils of Colorado" published July 1977, by CSU Experiment Station - Bulletin 566S.

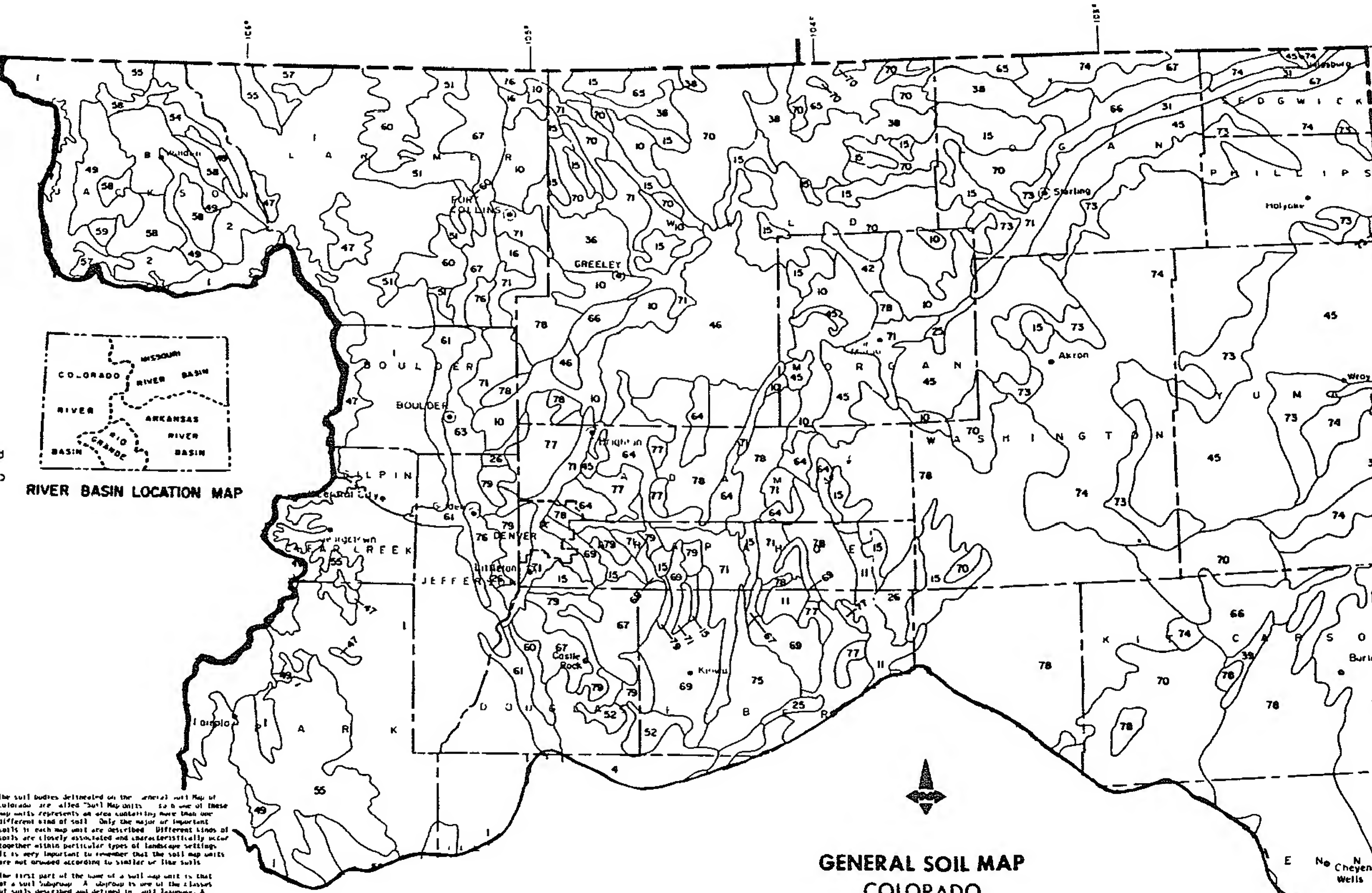
Assistance on the soils is available at the local Soil Conservation Service office. Published Soil Survey can also be obtained at these offices. "Important Farmlands" maps, which include prime land, are available for purchase through the Bulletin Room 171, S.W. Wing Aylesworth Hall, Colorado State University, Ft. Collins, Colorado 80523. Phone: (303) 491-6198.

Natural Basin Features

The Missouri River Tributaries, Colorado, contains all of the North and South Platte Rivers and Republican River drainages in Colorado. Figure 1 shows the location of the study area. The total area consists of 19,121,000 acres. Elevations in the basin vary from high mountain peaks of 14,000 plus feet above mean sea level and high mountain passes of 11,000 feet in the Rocky Mountains through foothills, plains and river bottomlands to about 3,400 feet mean sea level at Laird, Colorado. Two distinguishable major physical divisions characterize the basin.

The Rocky Mountain System occupies approximately 25 percent of the basin. The Southern Rocky Mountain province occupies all of the Rocky Mountain System while the High Plains province occupies all of the Interior Plains System. The Southern Rocky Mountain province has extensive areas of coniferous forests and intermingled mountain parks supporting mixed grasses and shrubs. There are a number of intermountain valleys between the mountain masses. These areas are used mainly for grazing. The Rocky Mountain portion of the basin is a primary source of water for the North and South Platte Rivers.

The High Plains province slopes gently eastward from the Rocky Mountains. It occupies approximately 75 percent of the basin. The plains are characterized by nearly level to rolling tablelands, with hilly to rough broken areas along the valley sides. Stream dissection is well established, with broad smooth divides between the larger drainages.



GENERAL SOIL MAP
COLORADO

MAY 1976

MISSOURI RIVER TRIBUTARIES
COLORADO

The soil bodies delineated on the General Soil Map of Colorado are called "Soil Map Units." Each one of these map units represents an area containing more than one different kind of soil. Only the major or important soils in each map unit are described. Different kinds of soils are closely associated and characteristically occur together within particular types of landscape settings. It is very important to remember that the soil map units are not grouped according to similar or like soils.

The first part of the name of a soil map unit is that of a soil Subgroup. A subgroup is one of the classes of soils described and defined in "Soil Taxonomy, A Basic System of Soil Classification for Making and Interpreting Soil Surveys." Terms describing the used soil textural classes, amounts of rock fragments and slopes complete the name.

This map was made by adapting delineations on more detailed soil maps available from the Soil Conservation Service and by predicting soil boundaries in areas where more detailed maps are not available.

LEGEND

ALFISOLS

BORALFS
Cryoboralfs
TYPIC CRYOBORALFS
1 Typic Cryoboralfs, skeletal-Rock Outcrop sloping to steep
2 Typic Cryoboralfs loamy, sloping to steep
Eutroboralfs
TYPIC EUTROBORALFS
3 Typic Eutroboralfs, clayey-Rock Outcrop steep
PSAMMENTIC EUTROBORALFS
4 Psammentic Eutroboralfs-Aridic Haploborolls loamy, gently sloping and sloping

ARIDISOLS

ARGIDS
Haplargids
TYPIC HAPLARGIDS - FRIGID
5 Typic Haplargids, loamy-Typic Torriorthents, skeletal nearly level and gently sloping
TYPIC HAPLARGIDS - MESIC
6 Typic Haplargids loamy, nearly level and gently sloping
BOROLLIC HAPLARGIDS
7 Borollic Haplargids-Borollic Calciorthids, loamy, nearly level to sloping
8 Borollic Haplargids-Typic Cryoborolls loamy, gently sloping to steep
9 Borollic Haplargids-Ustic Torriorthents loamy, nearly level to moderately steep
USTOLLIC HAPLARGIDS - MESIC
10 Ustollic Haplargids loamy, nearly level and gently sloping
11 Ustollic Haplargids-Ustic Torriorthents (shallow) loamy; gently sloping to steep
12 Ustollic Haplargids, loamy-Rock Outcrop gently sloping to steep
13 Ustollic Haplargids, silty-Ustollic Haplargids, loamy-Ustic Torriorthents, silty: nearly level to sloping
14 Ustollic Haplargids, clayey-Ustollic Haplargids, silty-Ustollic Paleargids, clayey: nearly level and gently sloping
15 Ustollic Haplargids, clayey-Ustic Torriorthents, loamy (shallow) gently sloping to steep
16 Ustollic Haplargids-Ustertic Camborthids: clayey; gently sloping and sloping
Natrargids
TYPIC NATRARGIDS - FRIGID
17 Typic Natrargids, clayey-Typic Torripsamments nearly level to moderately steep
USTOLLIC NATRARGIDS - MESIC
18 Ustollic Natrargids, clayey-Ustollic Haplargids, loamy nearly level to sloping
ORTHIDS
Calciorthids
TYPIC CALCIORTHIDS - FRIGID
19 Typic Calciorthids, skeletal-Borollic Calciorthids, loamy, nearly level to sloping
TYPIC CALCIORTHIDS - MESIC
20 Typic Calciorthids, skeletal-Ustic Torriorthents, loamy: gently sloping to moderately steep
Camborthids
BOROLLIC CAMBORTHIDS
21 Borollic Camborthids, clayey-Aridic Argiborolls, loamy gently sloping to moderately steep
BOROLLIC LITHIC CAMBORTHIDS
22 Borollic Lithic Camborthids, skeletal-Rock Outcrop; gently sloping to steep
BOROLLIC VERTIC CAMBORTHIDS
23 Borollic Vertic Camborthids, clayey, gently sloping to moderately steep
LITHIC CAMBORTHIDS - MESIC
24 Lithic Camborthids-Lithic Ustic Torriorthents: loamy; steep
USTERIC CAMBORTHIDS - MESIC
25 Usteric Camborthids clayey; nearly level
USTOLLIC CAMBORTHIDS - MESIC
26 Ustollic Camborthids Ustic Torriorthents (shallow): clayey, nearly level to sloping

ENTISOLS

AQUENTS
Psammaquents
TYPIC PSAMMAQUENTS - FRIGID
27 Typic Psammaquents-Typic Natrargids, loamy-Aquic Natrargids, loamy nearly level
FLUVENTS
Torrifluvents
TYPIC TORRIFLUVENTS - MESIC
28 Typic Torrifluvents silty; nearly level
USTIC TORRIFLUVENTS - FRIGID
29 Ustic Torrifluvents, loamy-Typic Fluvaquents, clayey, nearly level and gently sloping
USTIC TORRIFLUVENTS - MESIC
30 Ustic Torrifluvents loamy; nearly level and gently sloping
31 Ustic Torrifluvents-Typic Fluvaquents, loamy, nearly level
ORTHENTS
Cryorthents
LITHIC CRYORTHENTS
32 Lithic Cryorthents, skeletal-Rock Outcrop, steep
Torriorthents
TYPIC TORRIORTHENTS - MESIC
33 Typic Torriorthents (shallow), clayey, gently sloping to steep
USTIC TORRIORTHENTS - FRIGID
34 Ustic Torriorthents-Borollic Camborthids loamy, gently sloping to moderately steep
35 Ustic Torriorthents-Aridic Argiborolls, loamy, nearly level to sloping
USTIC TORRIORTHENTS - MESIC
36 Ustic Torriorthents loamy, gently sloping
37 Ustic Torriorthents-Ustollic Calciorthids loamy, nearly level
38 Ustic Torriorthents silty, nearly level and gently sloping (Brule materials)
39 Ustic Torriorthents silty, gently sloping to steep (loess)
40 Ustic Torriorthents, silty-Lithic Ustic Torriorthents, loamy: gently sloping
LITHIC USTIC TORRIORTHENTS - FRIGID
41 Lithic Ustic Torriorthents-Ustic Torriorthents, loamy, sloping to steep
LITHIC USTIC TORRIORTHENTS - MESIC
42 Lithic Ustic Torriorthents, loamy-Rock Outcrop, gently sloping to steep
Ustorthents
TYPIC USTORTHENTS - FRIGID
43 Typic Ustorthents: skeletal; nearly level
PSAMMENTS
Torripsamments
TYPIC TORRIPSAMMENTS - FRIGID
44 Typic Torripsamments, nearly level to steep
USTIC TORRIPSAMMENTS - MESIC
45 Ustic Torripsamments gently sloping to steep
46 Ustic Torripsamments-Ustollic Haplargids, loamy gently sloping to moderately steep

INCEPTISOLS

UMBREPTS
Cryumbrepts
PERGELIC CRYUMBREPTS
47 Pergelic Cryumbrepts, skeletal-Pergelic Cryochrepts, skeletal-Rock Outcrop sloping to steep

MOLLISOLS

AQUOLLS
Argiaquolls
TYPIC ARGIAQUOLLS - FRIGID
48 Typic Argiaquolls, loamy-Aeric Halaquepts, clayey-Typic Haplaquolls, loamy nearly level
Cryaquolls
TYPIC CRYAQUOLLS
49 Typic Cryaquolls-Argic Cryaquolls, loamy-Cumulic Cryaquolls loamy, nearly level and gently sloping
BOROLLS
Argiborolls
50 Aridic Argiborolls-Lithic Argiborolls skeletal, sloping to steep
51 Aridic Argiborolls, loamy-Rock Outcrop moderately steep and steep
52 Aridic Argiborolls-Aridic Haploborolls, clayey: gently sloping to steep
Calciborolls
ARIDIC CALCIBOROLLS
53 Aridic Calciborolls, skeletal-Aridic Calciborolls, loamy, sloping to steep
Cryoborolls
TYPIC CRYOBOROLLS
54 Typic Cryoborolls skeletal; nearly level to sloping
55 Typic Cryoborolls, loamy-Rock Outcrop sloping to steep
56 Typic Cryoborolls, clayey-Typic Cryoboralfs, skeletal moderately steep and steep
57 Typic Cryoborolls-Typic Cryorthents: clayey; sloping to steep
ARGIC CRYOBOROLLS
58 Argic Cryoborolls-Typic Cryoborolls, loamy, gently sloping to steep
59 Argic Cryoborolls-Cryic Paleborolls: loamy; nearly level to moderately steep
Haploborolls
ARIDIC HAPLOBOROLLS
60 Aridic Haploborolls, loamy-Torriorthentic Haploborolls, loamy-Aridic Argiborolls, clayey gently sloping to steep
LITHIC HAPLOBOROLLS
61 Lithic Haploborolls, skeletal-Rock Outcrop: moderately steep and steep
Paleborolls
TYPIC PALEBOROLLS
62 Typic Paleborolls-Borollic Camborthids: clayey; gently sloping to moderately steep
USTOLLS
Argiustolls
ARIDIC ARGIUSTOLLS - MESIC
63 Aridic Argiustolls, skeletal-Aridic Argiustolls, clayey: nearly level to steep
64 Aridic Argiustolls-Ustollic Haplargids loamy, nearly level to sloping
65 Aridic Argiustolls-Ustic Torriorthents (shallow): loamy; gently sloping to steep
66 Aridic Argiustolls, loamy-Aridic Argiustolls, silty, nearly level and gently sloping
67 Aridic Argiustolls-Aridic Haplustolls: loamy; gently sloping to moderately steep
68 Aridic Argiustolls-Lithic Haplustolls: loamy; gently sloping to steep
69 Aridic Argiustolls, loamy-Torriorthentic Haplustolls, sandy: nearly level and gently sloping
70 Aridic Argiustolls, loamy-Aridic Paleustolls, clayey: nearly level and gently sloping
71 Aridic Argiustolls, clayey-Ustollic Haplargids, loamy: nearly level
72 Aridic Argiustolls-Aridic Haploborolls, clayey: sloping to steep
PACHIC ARGIUSTOLLS - MESIC
73 Pachic Argiustolls, loamy-Aridic Argiustolls, loamy-Torriorthentic Haplustolls, sandy: nearly level and gently sloping
74 Pachic Argiustolls-Aridic Argiustolls: clayey and silty: nearly level
TORRERTIC ARGIUSTOLLS - MESIC
75 Torrertic Argiustolls-Ustic Torriorthents (shallow), clayey; gently sloping to steep
Haplustolls
LITHIC HAPLUSTOLLS - MESIC
76 Lithic Haplustolls, loamy-Aridic Argiustolls, loamy-Rock Outcrop: nearly level to steep
Paleustolls
ARIDIC PALEUSTOLLS - MESIC
77 Aridic Paleustolls-Ustollic Haplargids: clayey: nearly level to sloping
78 Aridic Paleustolls, clayey-Ustollic Paleargids, silty-Ustic Torriorthents, silty: nearly level to gently sloping
79 Aridic Paleustolls-Torrertic Argiustolls: clayey; nearly level to sloping

LAND TYPE

80 Dune Land

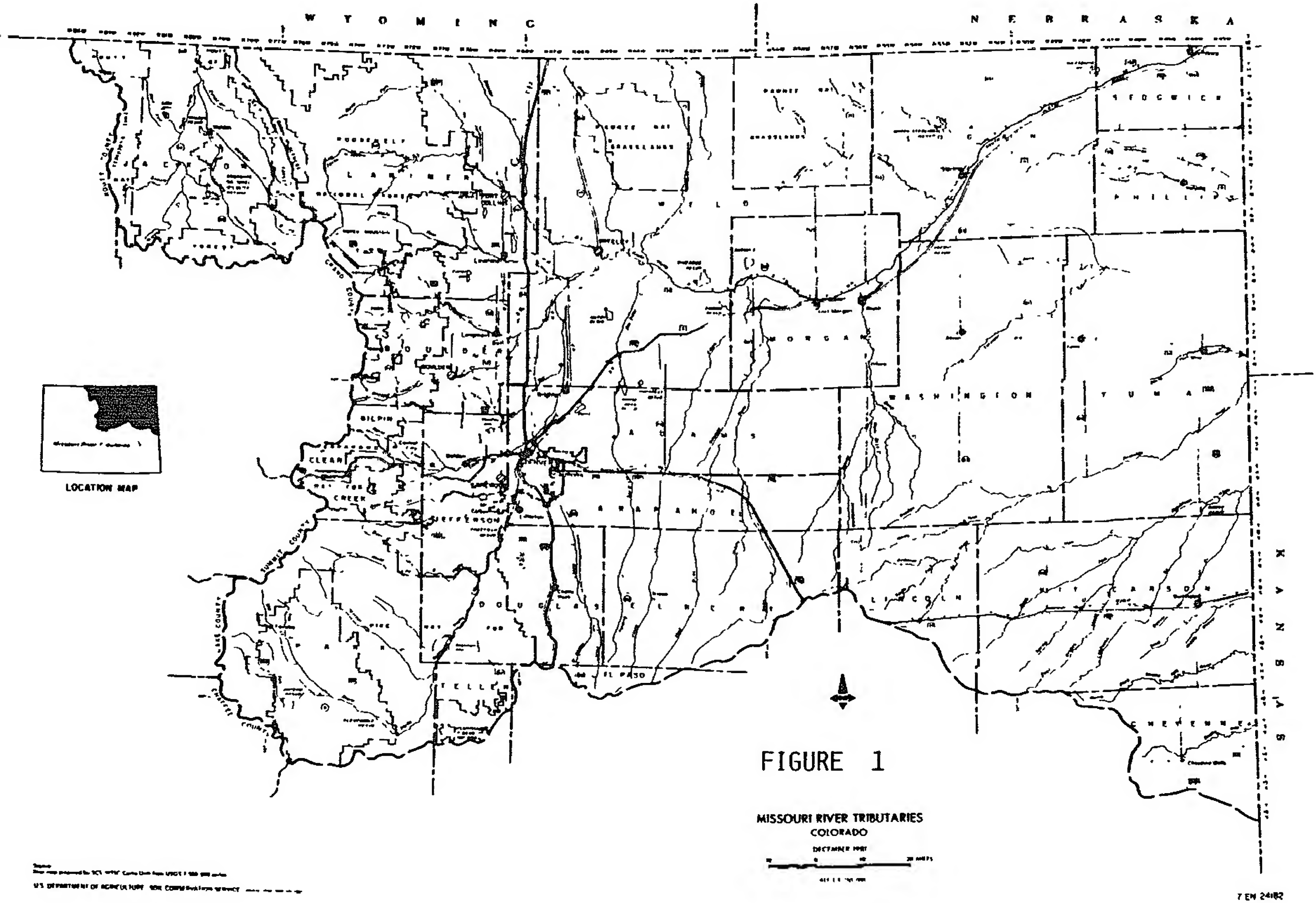


FIGURE 1

MISSOURI RIVER TRIBUTARIES
COLORADO

Geology

The mountainous areas of the basin are generally composed of hard crystalline and sedimentary rocks with granite predominating. In the geologic past, these rocks have been sculptured by ice and water to produce the rugged peaks and steep-sided valleys which form the alpine topography seen today. Some areas are covered by recent deposits of unconsolidated glacial till, sand, gravel, silts, and clays left behind by the continental glaciers. Erosion tends to be slow in these areas and the mountain streams generally carry very little sediment.

The plains areas are underlain by sedimentary rock formations consisting predominantly of clays, shales, silts, sands, and sandstones. Such areas erode much more readily than the older and more consolidated rocks of the mountainous areas. Much of the plains area is covered by younger alluvial and colian deposits of clay, silt, sand, and gravel.

Land Resources

From land and water stem the natural and renewable resources of agriculture, grass, forest, recreation, fish, and wildlife. The land and water resources have the potential, if properly managed and developed, to contribute to the satisfaction of demands and meet future needs.

The basin contains scenic mountains, narrow canyons, precipitous slopes, fertile valleys, broad plains, forests, grasslands, wetlands, lakes, and streams. Below the surface are extensive supplies of groundwater, coal, oil, gas, and other minerals. All these natural resources have and will continue to play a most important role in development of the basin.

The land resources of the basin are closely associated with their present uses (see Table B-1 and map). The best method to describe these resources is to indicate the current uses and to give an idea of their potential for future expansion.

Agriculture

About 88 percent (16,901,000 acres) of land in the basin are used for some agricultural purpose. Pasture and rangeland comprise the largest use and account for 38 percent of the total area. In addition, about 27 percent of the land is non-irrigated cropland, 8 percent is irrigated cropland, 14 percent is in forest, and 1 percent in other agriculture lands. The remaining 12 percent is devoted to non-agricultural and water uses.

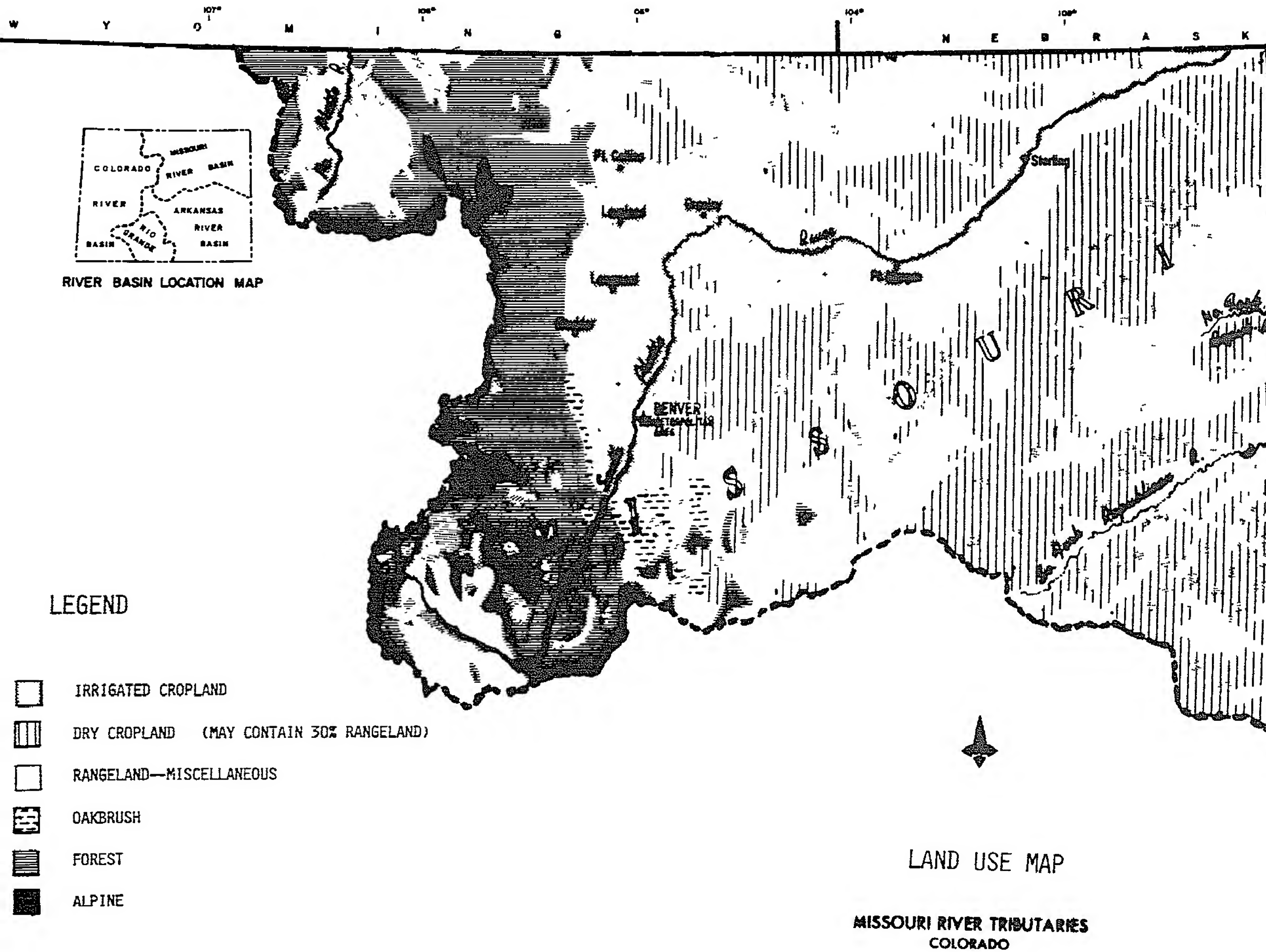
Shortage of water is a major limiting factor in agricultural production. Approximately 8 percent (1,580,000 acres) of the cropland is irrigated. Irrigation is practiced principally along the rivers and in the Ogallala Aquifer region. While surface water has made the greatest contribution, ground water also provides its portion. Water for irrigation has contributed not only to increases in the production of crops and livestock, but to the stability of the total agriculture and overall economy of the region.

Missouri River Tributaries, Colorado
Cooperative River Basin Study

Table B-1 - Land Resources

	North and South Platte Basins	Republican Basin	Total
	--------------------	1,000 ac.	--------------------
Cropland			
Nonirrigated	2,649	2,546	5,195
Irrigated	1,043	537	1,580
Pasture and Range	4,823	2,439	7,262
Forest	2,668	11	2,679
Other	123	62	185
Subtotal Ag	11,306	5,595	16,901
Non Ag Land			
Trans, Urban	664	92	756
Other	1,332	16	1,338
Subtotal Non Ag	1,986	108	2,094
Total Land Area	13,292	5,703	18,995
Total Water Area	103	23	126
Total Area	13,395	5,726	19, 121

Source: Missouri River Basin, Water Resources Plan, August 1977. 1975 estimate of the Missouri River Basin, Colorado.


W Y O M I N G
N E B R A S K
107°
106°
105°
104°
103°
COLORADO RIVER BASIN
MISSOURI RIVER BASIN
ARKANSAS RIVER BASIN
RIO GRANDE BASIN
RIVER BASIN LOCATION MAP
Ft. Collins
Sterling
Loveland
Greeley
Longmont
DENVER
M I S S O U R I
LEGEND
IRRIGATED CROPLAND
DRY CROPLAND (MAY CONTAIN 30% RANGELAND)
RANGELAND—MISCELLANEOUS
OAKBRUSH
FOREST
ALPINE
LAND USE MAP
MISSOURI RIVER TRIBUTARIES
COLORADO

There are approximately 7,262,000 acres (38 percent) of pasture and range for grazing of domestic livestock. Permits or leases are held by farmers and ranchers for grazing their livestock on the Federal lands. In addition, these pasture and rangelands provide habitat for wildlife and also provide areas for hunting and recreation.

Forests

Forests comprise approximately 14 percent (2,679,000) of the basin. A large portion of the forest lands are federally owned. These forests are predominately softwood or coniferous.

Elevation has an important bearing on the distribution of forest and their species composition. Trees seldom grow at less than 4,000 feet above sea level, except along river bottoms.

Minerals

Mineral resources of the basin can be described by grouping items into three categories: metallics, non-metallics, and fuels.

Metallic mineral resources are generally associated with mountainous areas and their peripheral outwash plains. Principal mineral production includes gold, silver, lead, zinc, manganese, molybdenum, and taconite.

Non-metallic minerals include fluorspar, limeston, pegmatite minerals, silica sand, and barite. Sillimanite and related minerals, kyanite and andalusite, along with barite, have been observed in deposits not yet considered as being commercial. Construction materials produced and used in the area are cement materials, various clays, crushed rock, gypsum, limestone, sand and gravel. Pumice and volcanic glass deposits are found but they have not been utilized.

Fuels - natural gas, petroleum, and coal represent important energy resources in the basin. Presently, oil and gas production occurs in the basin, primarily between Denver and Julesburg. Although coal production in the basin had ceased until recently, activity has increased.

Fish and Wildlife

Fish and wildlife resources in the basin are among the most outstanding in the nation. Wide varieties of habitat types, fostered by the extreme magnitude elevational differences and land uses within the basin, provide for a diversity of wildlife species. Elk in the more mountainous forested environs share this habitat with deer that merge into the habitats more identified with the plains. Where cropland has replaced rangeland, ringnecked pheasants have replaced prairie chickens that are now found in greatly reduced numbers in essentially relict mid-to-tall grass rangeland.

Both coldwater and warmwater fisheries are represented in the basin. The predominance of the coldwater fish, typically trout, are found in the permanent cold water streams, ponds, and reservoirs of the mountains and foothills; while warm water species, represented by bass, bluegill, channel catfish, and others are typically found in constructed ponds and reservoirs on the plains.

On the often watershort plains area, perhaps no habitat type is more important to wildlife than the cottonwood-willow community found along the creeks and streams. The importance of this narrow ribbon of riparion vegetation belies the small area it occupies, perhaps 1 percent of the land area. Its preservation and management are vital to the continued existence of much of the prairie fauna.

Recreation

Outdoor recreational opportunities range from the excitement of downhill skiing to backpacking and hiking activities in both the mountains and plains. Hunting, fishing, and a myriad of outdoor activities, attracting both residents and non-residents (tourists), are provided by the vast recreational resources of the basin.

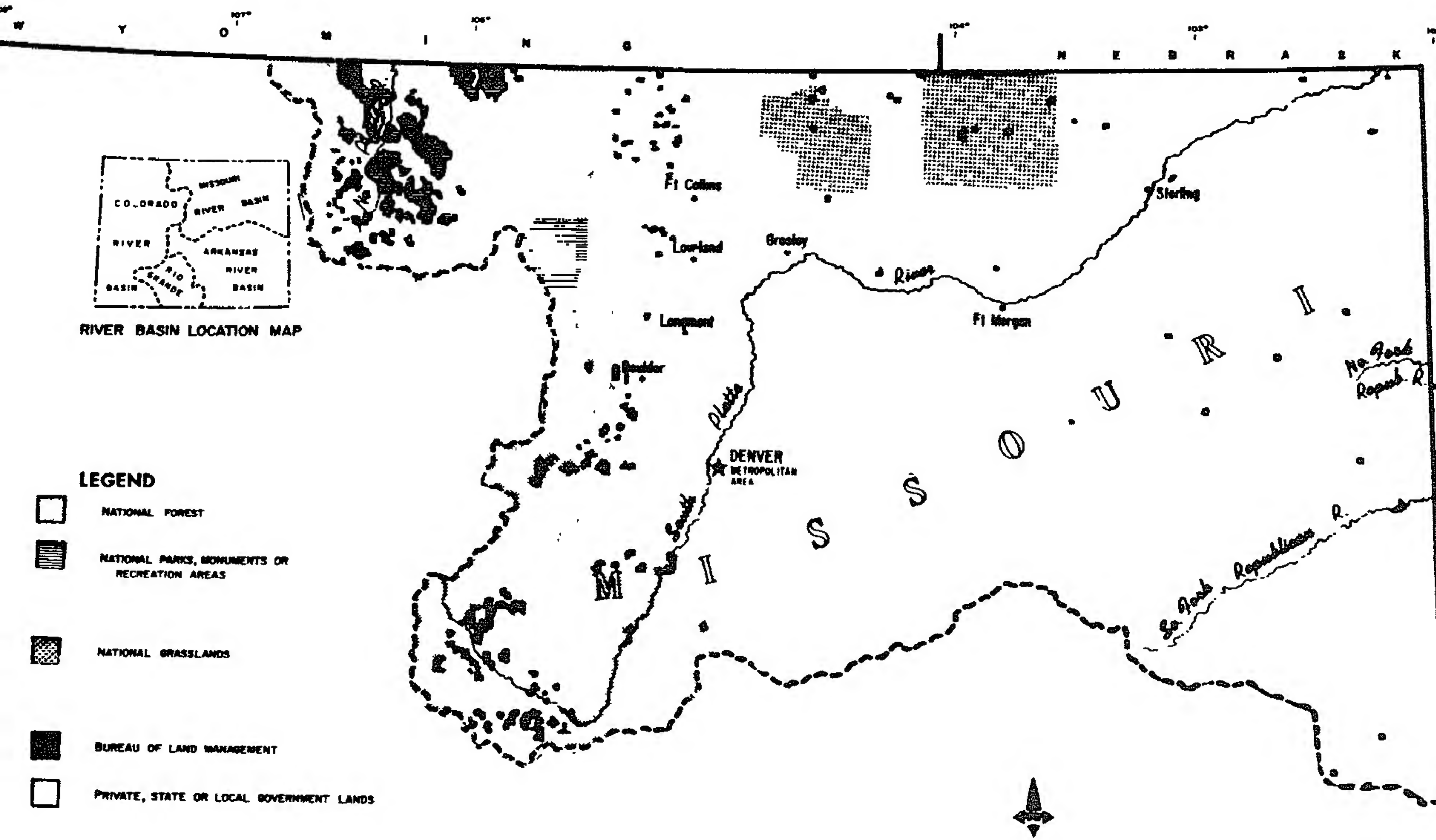
Land Ownership

The basin was included in the Louisiana Purchase of 1803. Title to the Louisiana Territory was delivered to the United States, thereby placing all of the area in federal ownership at the time of the purchase. Through sales, land grants, and various special and limited homestead acts passed by the Congress, most of the area passed to private and state ownership. (See map)

The farmers and ranchers are the largest landowners in the basin, within the "private-county-state category". State-owned lands, mostly school grant lands, are interspersed with private lands and are generally leased by the farmers and ranchers for agricultural purposes. Lands owned by the United States are managed by several federal agencies: The Forest Service, Bureau of Land Management, National Park Service, Corps of Engineers, and Bureau of Reclamation. Lesser acreages are managed by the Department of Defense, Department of Energy, Department of the Treasury, and Department of Justice.

Private Lands

The management of private lands within the basin is vested with thousands of individuals, corporations, and legal entities. Except for some general restrictions and zoning laws, these individual managers have traditionally had the right to use their land much as they see fit. It has been the decisions of these managers which have determined the present patterns of land use.



LAND OWNERSHIP MAP

MISSOURI RIVER TRIBUTARIES
COLORADO

Federal Lands

National Forest System is administered by the Forest Service. The basin has national forest and national grassland that are managed for water, timber, forage, wildlife, and recreation.

Public Domain is administered by the Bureau of Land Management. The basic federal management objective for these lands is to achieve their maximum use in the public interest, consistent with conservation, and with development of the productive capacity. These lands are managed with grazing, timber, water, forage, wildlife and recreation.

National Parks System has the Rocky Mountain National Park to administer. It is administered for the purpose of conserving scenery, wildlife, natural and historic objects, and provide for the enjoyment "in such manner and by such means as will leave them unimpaired for the enjoyment of future generations".

Reclamation Projects are managed by the Bureau of Reclamation. The multi-purpose management of these lands includes management for water storage, irrigation, municipal water supplies, recreation, fish and wildlife, power, and project service facilities.

Flood Control Projects - the Army Corps of Engineers, Department of the Defense, manages certain lands that were acquired primarily for flood control and resource development purposes. These lands are managed for multiple-purpose use that includes management for riverflow control, flood control, power development, navigation, irrigation, municipal water supply, recreation, and fish and wildlife.

Military - The Department of Defense owns and administers military areas such as Rocky Mountain Arsenal, Fort Logan, Lowry Air Force Base, Fitzsimmons Army Hospital, and missile sites. Specific administration is by the respective Agency (Army, Navy, or Air Force) that is using the land.

APPENDIX C

WATER SUPPLY

Surface Water

The total surface water supplies in the South Platte River Basin in Colorado have been estimated to average 1.8 million acre-feet annually of which abbut 336,000 acre-feet are attributed to transbasin imports.

The plains tributaries, such as Plum Creek, Cherry Creek, Box Elder Creek, Kiowa Creek, Bijou Creek, etc. flow more in response to summer rainstorms than from melting snow and therefore are not significant contributors to the basin water supply.

As much as 75 percent of the runoff of mountain streams may occur during the months of May through July as a consequence of melting mountain snowpacks. Generally speaking, the mountain snowpack starts building in October and continues until May. Low elevation snow begins melting in late April or early May with the higher elevation melt continuing into early July. The pronounced seasonal variations in streamflow explains the need for water storage facilities found throughout the basin.

Transbasin Diversion projects such as Colorado-Big Thompson project, the Moffat Collection system, etc. are important water supply sources for agriculture, and municipal industrial purposes.

Natural surface water supplies of the South Platte Basin in Wyoming and Colorado are shown in Table C-1.

By interstate compact, Colorado must let a specified amount of runoff flow into Nebraska each year (if it is available under certain stipulations). When imported water from other river basins is added to the basin native supply and applied to the various uses, it is not all consumptively used (especially during spring runoff). An estimate of annual water supplies and depletions is shown in Table C-2. A 1977 report prepared for the U. S. Army Corps of Engineers shows somewhat greater basin outflow than shown in Table C-2, and concludes that about 300,000 acre-feet per year is still available for Colorado use. The main reason this legally available water escapes from Colorado is a lack of storage capacity to detain spring runoff and return flows.

Existing reservoirs having individual capacities of 5,000 acre-feet or more are listed in Table C-3. Many of these reservoirs are managed to provide a basic irrigation water supply or to supplement direct streamflow diversions. It is necessary to analyse reservoir stages and include this information along with snow depths when forecasting the water supply each spring. Good reservoir storage conditions can off-set to some extent a below average snow depth situation within a basin.

There are thousands of reservoirs in the basin that have storage capacities less than 5,000 acre-feet (the number of these is not available). The smaller of these facilities are more useful for regulation of irrigation flows rather than to provide carry-over storage from year-to-year.

Municipal and industrial water supplies are a significant water source in the basin. This use is a major reason for the relatively large amount of imported water. For example, the Denver Water District served a population of over 950,000 during 1979 with a water supply of over 350,000 acre-feet of which only 150,000 acre-feet was native South Platte River water.

Groundwater

The valley fill alluvial acquifer of the South Platte River Basin in Colorado is estimated by some to store over 14 million acre-feet of groundwater. An estimated 1.3 million acre-feet of alluvial groundwater is withdrawn annually through pumping, principally for irrigation.

The alluvium ranges from 3 to 8 miles wide and zero to 240 feet thick (saturated). The depth to water ranges from 10 to 100 feet.

The alluvium is recharged by precipitation, applied irrigation water, and leakage from canals, reservoirs and stream channels. Recharge from applied irrigation water and leakage from canals to the alluvium is estimated to be 45 to 50 percent of the diverted irrigation water.

Table C-1 Native Surface Water Runoff of the South Platte River Basin in Wyoming and Colorado.

-basin	Drainage Area (Square Miles)	Long Term Average	Surface Water Runoff (Acre-feet/Year)1/ 1970 Water Year Annual Flow	% of Long Term Average	1953-56 Drought Period Avera Annual Flow	% of Long Te Average
th Platte River Mountains	2,142	201,211	402,235	199.9	105,354	52.4
th Fork South Platte River	479	112,604	198,680	176.4	64,286	57.1
n Creek	302	22,789	31,440	138.0	7,142	31.3
ry Creek	385	11,075	6,119	55.3	4,606	41.6
Creek	214	44,927	76,244	169.7	4,411	9.8
ar Creek	448	173,994	225,362	129.5	114,784	66.0
der Creek	439	122,832	162,914	132.6	83,824	68.2
t Vrain Creek	537	117,600	131,549	111.9	74,820	63.6
Thompson River	828	147,600	177,006	119.9	93,903	63.6
e La Poudre River	1,877	234,833	321,220	136.8	158,066	67.3
h Platte River Transition	1,447	12,341	9,074	73.5	5,133	41.6
Creek	1,824	60,000	60,000	100.0	36,540	60.9
h Plains Tributaries	2,400	1,090	1,090	100.0	664	60.9
e Pole Creek	1,946	43,023	43,023	100.0	26,201	60.9
h Plains Tributaries	4,276	50,000	50,000	100.0	30,450	60.9
h Platte River-Plains	1,956	0	0		0	
n Total	21,500 2/	1,355,919	1,895,956	139.8	825,590	60.9

ppendix A. The figures above do not include "return flows" from municipalities and industries; groundwater which trates to these streams sustaining flows in their plains reaches is not included either. This phenomena is the resul asins history of irrigation. Return flows from agriculture are the residual of applied irrigation water which seep t round, accrue back to the streams, and allows for their use once again. Because of this, total surface water diversi e much greater than total surface water runoff, however, total consumptive use is never greater (discounting imports d water use).

he drainage area of the entire South Platte River Basin is 24,300 square miles, (USGS, 1970). However, the 2,800 sq in Nebraska are not included in the study area.

e: Water and Related Land Resource Management Study, Vol. 2, Technical Appendix by U.S. Army Corps of Engineer

Table C-2 Annual Water Supplies and Depletions

(1,000 acre-feet)

Basin and Subbasin	Water Supplies				Water Depletions 1/				Basin Outflow
	Native 2/	Exports 3/	Imports 3/	Available	Irrigation 4/	M&I and Rural Domestic 5/	Other	Total	
Missouri River									
North Platte River	600	22 7/	0	578	108	1	1	110	468
South Platte River	1,441	0	336 7/	1,777	1,251	164	58	1,473	304
Kansas River	353	0	0	353	220	3	8	231	122
Basin Total	2,394	0	314 8/	2,708	1,579	168	67	1,814	894 6/

1/ Estimated depletions under 1970 conditions of development
2/ Undepleted average annual water supply
3/ 1968 to 1970 annual average
4/ Irrigation consumptive use and associated consumptive reservoir and conveyance losses
5/ Rural domestic, municipal and industrial consumptive uses and related reservoir losses
6/ 1950 to 1970 annual average
7/ Includes internal basin diversions of 22,000 acre-feet from North Platte River to the South Platte River
8/ Includes 14,000 acre-feet evaporation attributable to imports from Colorado River

Source: "Water for Tomorrow, Colorado State Water Plan, Phase I - Appraisal Report" by U. S. Bureau of Reclamation and Colorado Department of Natural Resources.

Table C-3 Storage reservoirs in the study area by subarea and capacity (over 5,000 acre-feet)

Name of Development	Functions*	Description, including acre-feet
COLORADO		
Antero Park Reservoir	M	Owned and operated by Denver Water Board, reservoir capacity - 22,290 acre-feet
Eleven Mile Canyon Reservoir	I-M	Owned and operated by Denver Water Board, reservoir capacity - 97,520 acre-feet
Cheesman Lake	M	Owned and operated by Denver Water Board, reservoir capacity - 79,060 acre-feet
Chatfield Lake	FC-F-R	Corps of Engineers, reservoir capacity - 235,000 acre-feet
Marston Lake	M	An offstream reservoir used by the Denver Water Board for temporary storage of municipal water - capacity 16,500 acre-feet
Cherry Creek Dam and Reservoir	FC-R	Corps of Engineers, reservoir capacity - 95,000 acre-feet
Ralston Reservoir	M	Stores transmountain diversions which come from Gross Reservoir down Boulder Creek, thence to Ralston by 9.6 mile long conduit. Water used for Denver's winter municipal supply. Capacity - 11,270 acre-feet
Barr Lake	I	Offstream reservoir - capacity 32,140 acre-feet
Gross Reservoir	M	Provides storage and regulation of Denver's transmountain diversions through Moffat Tunnel. Reservoir capacity - 43,060 acre-feet
Standley Lake	I-M	Stores water from Coal & Woman Creeks and Farmers Highline Canal. Supplies some municipal water to Westminister, Colorado. Reservoir capacity - 10,260 acre-feet
Horse Creek Reservoir	I	A Bureau of Reclamation offstream reservoir. Capacity - 16,970 acre-feet
Prospect	I	Storage - 5,610 acre-feet

Table C-3 Storage reservoirs in the study area by subarea and capacity (Con't - 2) (over 5,000 acre-feet)

Name of Development	Functions*	Description, including acre-feet
COLORADO		
Reservoir No. 22	M	Storage - 41,920 acre-feet
Marshall Lake	I	Offstream reservoir. Capacity - 10,260 acre-feet
Barkers Meadow Reservoir	P	Reservoir capacity - 11,680 acre-feet, 20,000 kW - operated by Colorado Public Service Co.
Base Line	I	Storage - 5,380 acre-feet
Pamona Reservoir	I	Storage - 7,000 acre-feet
Six Mile Reservoir	I	Offstream reservoir, 10,850 acre-feet
Colorado Big Thompson Project	I-P-M-R-F	Bureau of Reclamation transmountain diversion - Colorado River - 10 reservoirs, 6 powerplants, 183,950 kW, 3 pumping plants, 34 miles tunnels, supplemental irrigation - 994,360 acre-feet
Joe Wright Reservoir	I-M-R	Storage water for city of Ft. Collins; 7,056 acre-feet usable storage.
Long Draw Reservoir	I	Reservoir capacity 11,000 acre-feet.
Boyd Lake	I	Originally constructed for power purpose. Converted to irrigation use in 1927. Offstream reservoir with 44,020 acre-feet capacity
Home Supply	I	Soil Conservation Service's 38-mile channel rehabilitation 1 storage reservoir, 5,000 acre-feet
Louden	FC-I	Soil Conservation Service's 1 multipurpose structure, capacity - 5,000 acre-feet
Lake Loveland	I-M	Offstream reservoir, capacity - 14,240 acre-feet
Union Reservoir	I	Offstream reservoir, capacity - 12,740 acre-feet
Milton Reservoir	I	Offstream reservoir, capacity - 31,130 acre-feet

Table C-3 Storage reservoirs in the study area by subarea and capacity (Con't - 3) (over 5,000 acre-feet)

Name of Development	Functions*	Description, including acre-feet
COLORADO		
Lower Latham	I	Storage - 5,760 acre-feet
Chambers Lake	I	Storage - 8,824 acre-feet
Douglas	I	Storage - 6,000 acre-feet
North Poudre No. 15	I	Storage - 5,500 acre-feet
Terry Lake	I	Storage - 9,700 acre-feet
North Poudre No. 6 Reservoir	I	Offstream reservoir, capacity - 10,260 acre-feet
Timnath Lake	I	Storage - 10,000 acre-feet
Bear Creek Dam and Lake	FC-F-R	Built by the Corps of Engineers primarily for flood control - capacity 46,410 acre-feet
Fossil Creek Reservoir	I	Reservoir capacity - 11,540 acre-feet
Reservoir No. 8	I	Offstream reservoir, capacity - 15,400 acre-feet
Cobb Lake	I	Storage - 9,120 acre-feet
North Platte No. 5	I	Storage 5,750 acre-feet
Park Creek Reservoir	I	Offstream storage - 7,320 acre-feet
Halligan No. 16	I	Storage - 6,500 acre-feet
Black Hollow	I	Storage - 8,000 acre-feet
Windsor Reservoir	I	Offstream reservoir, capacity - 15,620 acre-feet
Empire Reservoir	I	Offstream reservoir, capacity - 37,700 acre-feet
Jackson Lake Reservoir	I	Offstream reservoir, capacity - 35,630 acre-feet
Bijou No. 2	I	Storage - 6,000 acre-feet
Prewitt Reservoir	I	Offstream reservoir, capacity - 32,900 acre-feet

Table C-3 Storage reservoirs in the study area by subarea and capacity (Con't - 4) (over 5,000 acre-feet)

Name of Development	Functions*	Description, including acre-feet
COLORADO		
Point of Rocks Reservoir (North Sterling)	I	Offstream reservoir, capacity - 81,350 acre-feet
Julesburg (Jumbo)	I	Offstream reservoir, capacity - 27,200 acre-feet
MacFarlane	I	6,500 acre feet

* Function symbols:

I - Irrigation
F - Fish and Wildlife
FC - Flood Control and Detention
M - Municipal and Industrial Water
P - Power
R - Recreation

Source: "Water Use and Management in The Upper Platte River Basin", by Bureau of Reclamation

APPENDIX D

WATER QUALITY

Surface Water Quality

The mainstream South Platte River and its major tributaries exhibit wide variations in water quality. A general conclusion is that average concentrations of dissolved solids and major ions tend to increase in the mainstream South Platte River from Henderson to Julesburg. This is felt to be the combined effect of water re-use, increased use for irrigated agriculture, and percolation of return flows through sedimentary soils. Table D-1 shows a summary of stream quality at selected locations.

Groundwater Quality

Water pumped from the valley-fill alluvium is characterized by dissolved solids concentrations ranging from 100 to 4,000 mg/1, indicating a range from acceptable to impaired water quality. Available groundwater qualtiy maps show total dissolved solids content to be between 500 to 1000 mg/1 along the Platte River between Denver and the St. Vrain Creek confluence. From there to the State line the quality is between 1,000 and 2,000 mg/l. There are localized areas with groundwater quality at 2,000 to 4,000 mg/l.

TABLE D-1
SUMMARY OF STREAM QUALITY 1/
(Means Values, Milligrams Per Liter Unless Otherwise Specified)

ation	Bicarbonate	Chloride	Sulfate	Calcium	Magnesium	Sodium	Dissolved Solids	Specific Conductar (Micromhos
uth Platte River at Henderson, lorado (06720500)	220	85	160	73	17	100	580	960
. Vrain Creek at mouth, near atteville, Colorado (06731000)	280	28	520	100	74	120	1,190	1,390
g Thompson River at mouth, near Salle, Colorado (06744000)	330	22	890	170	110	150	1,890	1,960
che La Poudre River near Greeley, lorado (06752500)	350	44	640	160	82	120	1,470	1,670
uth Platte River near Kersey, lorado (06754000)	290	45	520	140	64	120	1,100	1,470
uth Platte River at Masters, lorado (06756995)	300	59	530	140	61	140	1,100	1,500
uth Platte River near Weldona, lorado (06758500)	310	68	660	160	71	160	1,500	1,750
jou Creek near Ft. Morgan, lorado (06759100)	320	56	600	200	41	140	1,270	1,660
uth Platte River at Balzac, lorado (06760000)	290	58	690	170	65	150	1,370	1,720
uth Platte River at Julesburg, lorado (067640000)	280	68	680	180	54	160	1,360	1,750

Source: Modified from Gaydos, 1980. Details of sample sizes and approximate period of record are given in that r

APPENDIX E

POPULATION

Total Population

The total land area of the Missouri River Basin is 28.7% of the entire State of Colorado. The 1980 Basin's population was about 69% of the State's population. The population density of both the Basin and the State showed increases over the 20 year period (1960-1980), but the Basin's density was somewhat greater than the State's.

Several changes in population occurred in the Missouri tributaries Basin in the twenty years between 1960 and 1980. Four counties suffered a decline in population which was offset by growth in the sixteen remaining counties for an overall 73.4% increase in the Basin. The rural agricultural counties either lost population slightly or had just a small population increase over the 20 year period. The rural nonfarm counties such as Clear Creek and Park Counties had a significant increase in population due to tourism (see Table E-1).

In contrast, the urban counties grew significantly. The Missouri tributaries Basin area has 3 Standard Metropolitan Statistical Areas 1/ (SMSA). They are the following:

1. Denver Boulder SMSA (Boulder, Jefferson, Douglas, Denver, Gilpin, Adams and Arapahoe counties).

2. Fort Collins SMSA (Larimer County).

3. Greeley SMSA (Weld County).

Table E-2 shows that in 1980 the 3 SMSA's had 95.3% of the basins population and 65.5% of the states population.

For the remaining counties, other than the counties in the 3 SMSA, the population for 1960 was 90,437, 1970 was 90,513 and 1980 was 93,079.

1/ SMSA has one or more central counties containing the areas main population and greater than 50,000 inhabitants generally in at least one central city.

Missouri Tributaries River Basin, Colorado 2/

County	Year	Population	Change in Population Percent	Period
Adams	1960	120,296		
	1970	185,789	54.4	1960-1970
	1980	245,944	32.4	1970-1980
Arapahoe	1960	113,426		
	1970	162,142	42.9	1960-1970
	1980	293,621	81.1	1970-1980
Boulder	1960	74,254		
	1970	131,889	77.6	1960-1970
	1980	189,625	43.8	1970-1980
Clear Creek	1960	2,793		
	1970	4,819	72.5	1960-1970
	1980	7,308	51.6	1970-1980
Denver	1960	493,887		
	1970	514,678	4.2	1960-1970
	1980	491,396	-4.5	1970-1980
Douglas	1960	4,816		
	1970	8,407	74.6	1960-1970
	1980	25,153	199.2	1970-1980
Elbert	1960	3,708		
	1970	3,903	5.3	1960-1970
	1980	6,850	75.5	1970-1980
Gilpin	1960	685		
	1970	1,272	85.7	1960-1970
	1980	2,441	91.9	1970-1980
Jackson	1960	1,758		
	1970	1,811	3.0	1960-1970
	1980	1,863	2.9	1970-1980
Jefferson	1960	127,520		
	1970	233,031	82.7	1960-1970
	1980	371,741	57.9	1970-1980
Kit Carson	1960	6,957		
	1970	7,530	8.2	1960-1970
	1980	7,599	0.9	1970-1980
Larimer	1960	53,343		
	1970	89,900	68.5	1960-1970
	1980	149,184	65.9	1970-1980

Table E-1 - The Population of the
Missouri Tributaries River Basin, Colorado 2/ (Con't)

County	Year	Population	Change in Population Percent	Period
Logan	1960	20,302		
	1970	18,852	-7.1	1960-1970
	1980	19,800	5.0	1970-1980
Morgan	1960	21,192		
	1970	20,105	-5.1	1960-1970
	1980	22,513	12.0	1970-1980
Park	1960	1,822		
	1970	2,185	19.9	1960-1970
	1980	5,333	144.1	1970-1980
Phillips	1960	4,440		
	1970	4,130	-7.1	1960-1970
	1980	4,542	9.9	1970-1980
Sedgewick	1960	4,242		
	1970	3,405	-19.7	1960-1970
	1980	3,266	-4.1	1970-1980
Washington	1960	6,625		
	1970	5,550	-16.2	1960-1970
	1980	5,304	-4.4	1970-1980
Weld	1960	72,344		
	1970	89,297	23.4	1960-1970
	1980	123,438	38.2	1970-1980
Yuma	1960	8,912		
	1970	8,544	-4.1	1960-1970
	1980	9,682	13.3	1970-1980
Basin	1960	1,145,507		
	1970	1,497,239	30.7	1960-1970
	1980	1,986,603	32.7	1970-1980
State	1960	1,753,947		
	1970	2,207,259	25.8	1960-1970
	1980	2,889,964	30.9	1970-1980

2/ Source: 1960, 1970, 1980 Bureau of Census, U.S. Department of Commerce.

Table E-2 - Population of the SMSA's of Denver-Boulder, Ft. Collins and Greeley Missouri Tributaries River Basin, Colorado 2/

		Population		
Year	Total	Change in Population %	Percent of Basin	Percent of State
		Denver - Boulder SMSA		
1960	929,383		81.1	53.0
1970	1,227,529	32.1	82.0	55.6
1980	1,620,902	31.0	81.6	56.1
		Fort Collins SMSA		
1960	53,343		4.7	3.0
1970	89,900	68.5	6.0	4.1
1980	149,184	65.9	7.5	5.2
		Greeley SMSA		
1960	72,344		6.3	4.1
1970	89,297	23.4	6.0	4.0
1980	123,438	38.2	6.2	4.3
		3 SMSA's Combined		
1960	1,055,070		92.1	60.2
1970	1,406,726	33.3	94.0	63.7
1980	1,893,524	34.6	95.3	65.5

2/ Source: 1960, 1970, 1980 Bureau of Census, U.S. Department of Commerce.

APPENDIX F

Agricultural Sales 1/

Table F-1 shows farm cash receipts and acreages for the Missouri Tributaries Basin and the State of Colorado. The Basin and the State have shown a steady increase in total sales from 1964 to 1982.

While the Basin contained about 37% of the State's farmland, it contributed 60% of the State's total sales (1982). Over this period the average sales per farm rose steadily in the Basin and the State, but the Basin average remained well above that for the State. Most of the counties in the Basin were consistently higher in average sales per farm than the State. Weld and Yuma counties had the largest sales.

The proportion of sales attributed to crops versus livestock has fluctuated about 5% during the years in question. Livestock sales in 1982 were responsible for 72% of the total farm sales for the Missouri Tributaries Basin and 71% for Colorado.

1/ Source - Colorado Census of Agriculture. 1964, 1974 & 1982 Bureau of Census, Department of Commerce.

Table F-1 - Farm Cash Receipts
Missouri Tributaries River Basin, Colorado 1/

		All Farms			Average/Farms		
County	Year	# Of Farms	Acres of Farmland	Total Sales $1000	Acre/ Farm	Average Sales/Farm $	Crops As % of Sales
Adams	1964	863	657,135	27,169	984	40,672	22
	1974	760	802,278	54,587	1,056	71,825	50
	1982	764	728,054	97,157	953	127,169	43
Arapahoe	1964	321	501,802	5,589	2,018	23,384	53
	1974	278	415,704	12,682	1,495	45,619	80
	1982	301	285,440	15,014	948	49,880	76
Boulder	1964	744	276,793	16,055	490	31,297	17
	1974	563	122,805	20,801	218	36,947	32
	1982	761	161,545	46,833	212	61,541	27
Clear Cr.	1964	5	8,319	27	2,461	13,634	50
	1974	NA	NA	NA	NA	NA	NA
	1982	NA	NA	NA	NA	NA	NA
Denver	1964	58	419	3,069	8	57,908	86
	1974	39	510	4,084	13	94,983	100
	1982	36	NA	2,768	NA	76,899	98
Douglas	1964	286	346,444	3,737	1,651	19,267	8
	1974	250	273,393	6,265	1,094	25,060	53
	1982	401	227,196	15,428	565	38,475	35
Elbert	1964	579	1,051,179	6,500	2,120	13,860	10
	1974	513	1,080,532	15,219	2,106	29,667	29
	1982	611	1,010,396	25,078	1,654	41,045	23

Table F-1 - Farm Cash Receipts
Missouri Tributaries River Basin, Colorado 1/ (Con't - 2)

		All Farms			Average/Farms		
County	Year	# Of Farms	Acres of Farmland	Total Sales $1000	Acre/ Farm	Average Sales/Farm $	Crops As % of Sales
Gilpin	1964	9	10,539	6	1,806	1,233	0
	1974	NA	NA	NA	NA	NA	NA
	1982	15	9,365	31	624	2,093	NA
Jackson	1964	83	371,457	2,692	4,524	32,830	12
	1974	92	470,485	5,531	5,114	60,120	26
	1982	123	449,137	12,023	3,652	97,751	14
Jefferson	1964	390	198,001	4,958	645	20,402	53
	1974	248	86,863	8,848	350	35,677	80
	1982	475	114,389	12,602	241	26,530	83
Kit Carson	1964	760	1,272,624	15,107	1,829	22,315	46
	1974	842	1,373,716	97,423	1,631	115,704	52
	1982	762	1,266,879	136,461	1,663	179,083	38
Larimer	1964	1,194	740,786	24,793	803	28,079	24
	1974	945	721,867	53,996	764	57,139	29
	1982	1,129	548,063	86,401	485	76,529	20
Logan	1964	1,092	1,181,243	40,875	1,158	41,625	21
	1974	1,031	1,149,769	144,983	1,115	140,624	23
	1982	908	1,071,104	131,389	1,180	144,702	25
Morgan	1964	1,056	818,360	51,174	812	53,196	23
	1974	934	748,407	148,686	801	159,193	24
	1982	846	696,308	166,959	823	197,351	24

Table F-1 - Farm Cash Receipts
Missouri Tributaries River Basin, Colorado 1/ (Con't - 3)

		All Farms			Average/Farms		
County	Year	# Of Farms	Acres of Farmland	Total Sales $1000	Acre/ Farm	Average Sales/Farm $	Crops As % of Sales
Park	1964	96	509,486	1,481	6,534	19,742	5
	1974	80	366,281	1,579	4,579	19,738	12
	1982	146	404,910	2,109	2,773	14,446	18
Phillips	1964	460	479,093	5,983	1,114	14,280	43
	1974	444	467,309	45,017	1,052	101,390	75
	1982	427	463,171	76,347	1,085	178,800	57
Sedgwick	1964	356	339,154	9,135	1,050	28,907	43
	1974	302	341,713	28,109	1,132	93,076	56
	1982	253	324,967	39,741	1,284	157,078	51
Washington	1964	885	1,431,132	11,167	1,745	14,064	34
	1974	906	1,381,515	49,212	1,524	54,318	65
	1982	854	1,365,488	72,279	1,599	84,635	56
Weld	1964	3,419	2,158,581	158,510	675	51,632	25
	1974	3,074	2,351,902	601,317	765	195,614	19
	1982	3,059	1,981,317	829,180	648	271,062	15
Yuma	1964	1,009	1,456,038	14,192	1,580	15,964	34
	1974	1,065	1,433,473	90,826	1,346	85,283	61
	1982	997	1,416,756	180,350	1,421	180,893	45
Basin	1964	13,665	13,808,585	402,131	1,011	29,428	27
	1974	12,366	13,588,522	1,389,165	1,099	112,337	33
	1982	12,868	12,524,485	1,948,150	973	151,395	28

Table F-1 - Farm Cash Receipts
Missouri Tributaries River Basin, Colorado 1/ (Con't - 4)

County	Year	All Farms: # Of Farms	All Farms: Acres of Farmland	All Farms: Total Sales $1000	Average/Farms: Acre/ Farm	Average/Farms: Average Sales/Farm $	Average/Farms: Crops As % of Sales
State	1964	29,798	38,258,626	605,090	1,537	26,134	30
	1974	25,501	35,902,165	1,970,236	1,408	77,261	35
	1982	27,117	33,560,333	2,941,986	1,238	108,492	29

1/ Source: Colorado Census of Agriculture: 1964, 1974 and 1982, Bureau of Census, Department of Commerce.
NA Not available.

APPENDIX G

CROP AND LIVESTOCK PRODUCTION

Nine important crops raised in the Missouri Tributaries River Basin were selected for comparison for the years 1964, 1974, and 1982: winter wheat, corn for grain, barley, sorghum grain, dry beans, sugar beets, potatoes, all hay, and corn silage. The basin is the largest producer of corn grain, wheat, sugar beets, corn silage, hay, and dry beans of any basin in Colorado. (See Table G-1)

During the periods 1964 to 1974 and 1974 to 1982, there was a dramatic increase in winter wheat and corn grain grown in the basin and state. Corn silage production rose in the basin and state in 1974, but dropped slightly in 1982.

Corn for grain production rose dramatically from 1964 to 1982. It increased in importance in the basin over the 20 year period, and contributed about 91% of the State's total crop. Yuma County was the basin's largest producer in 1982. About 81% of the state's corn silage was grown in the basin.

Of particular interest is the importance of the basin as a producer of winter wheat. The basin raised 65% of the State's crop in 1982. Kit Carson County was the leading wheat producer in 1982.

Weld County led the Basin in all crops except sorghum, wheat and corn for grain.

Of these 9 crops the basin grows the majority of all except for barley, potatoes and sorghum. Yields are shown in Table G-2.

The basin produced more than 1/2 of the State's production of each of the livestock categories except sheep and lambs as shown on Table G-3. Sheep and lamb decrease significantly from 1964 to 1982. Weld County was the largest producer of all counties in the basin in 1982 for each livestock category except for hogs and pigs.

The majority of the land area in Jackson County is in the North Platte River Drainage while the majority of the land area in Kit Carson, Phillips and Yuma Counties fall in the Republican Drainage. The remaining counties in the tables in Appendix G are in the South Platte River Drainage area.

Table G-1 - Crop Production
Missouri Tributaries River Basin, Colorado 1/
(1,000)

County	Year	Winter Wheat BU.	Corn Grain BU.	Barley BU.	Sorghum Grain BU.	Sugar Beets Tons
Adams	1964	1,510	175	22	1	52
	1974	4,227	425	256	10	27
	1982	5,569	560	202	74	NA
Arapahoe	1964	588	1	98	3	1
	1974	1,043	NA	50	0	0
	1982	1,209	NA	17	3	0
Boulder	1964	383	211	396	2	65
	1974	209	347	259	0	38
	1982	160	848	231	0	15
Clear Cr.	1964	NA	NA	NA	NA	NA
	1974	NA	NA	NA	NA	NA
	1982	NA	NA	NA	NA	NA
Denver	1964	NA	NA	NA	NA	NA
	1974	NA	NA	NA	NA	NA
	1982	NA	NA	NA	NA	NA
Douglas	1964	102	0	19	0	0
	1974	124	NA	18	0	0
	1982	101	NA	15	0	0
Elbert	1964	485	1	43	3	0
	1974	1,205	10	30	0	0
	1982	1,493	0	21	10	0
Gilpin	1964	NA	NA	NA	NA	NA
	1974	NA	NA	NA	NA	NA
	1982	NA	NA	NA	NA	NA
Jackson	1964	1	0	0	0	0
	1974	0	0	0	0	0
	1982	0	0	0	0	0
Jefferson	1964	118	0	35	2	0
	1974	79	0	27	0	0
	1982	45	0	6	0	0
Kit Carson	1964	2,601	771	89	1,080	135
	1974	6,765	6,102	58	115	289
	1982	9,939	6,537	289	565	50
Larimer	1964	391	313	769	2	181
	1974	487	702	566	0	113
	1982	306	2,362	602	0	63

Table G-1 - Crop Production
Missouri Tributaries River Basin, Colorado 1/ (Con't - 2)
(1,000)

County	Year	Winter Wheat BU.	Corn Grain BU.	Barley BU.	Sorghum Grain BU.	Sugar Beets Tons
Logan	1964	2,098	658	36	40	207
	1974	4,847	2,534	64	2	175
	1982	4,750	5,286	50	45	84
Morgan	1964	796	2,649	240	36	367
	1974	1,893	5,442	166	35	180
	1982	1,652	10,191	149	84	114
Park	1964	0	0	0	0	0
	1974	0	0	0	0	0
	1982	0	0	0	0	0
Phillips	1964	1,410	175	10	221	5
	1974	4,267	4,403	10	67	89
	1982	5,224	9,011	31	45	65
Sedgwick	1964	1,160	379	132	60	105
	1974	2,440	1,554	18	4	44
	1982	2,550	4,493	12	10	36
Washington	1964	2,243	195	148	63	11
	1974	8,944	1,302	63	41	29
	1982	9,075	3,428	81	69	25
Weld	1964	2,250	2,903	1,922	11	1,263
	1974	5,252	7,838	1,412	5	746
	1982	4,036	18,327	1,417	80	381
Yuma	1964	2,413	499	135	744	30
	1974	4,964	11,919	17	201	177
	1982	4,925	24,663	105	209	69
Basin	1964	18,549	8,930	4,094	2,263	2,422
	1974	46,746	42,578	3,014	480	1,907
	1982	51,034	85,706	3,228	1,194	902
State	1964	23,827	10,990	8,948	7,820	2,806
	1974	70,089	50,167	9,718	7,732	2,175
	1982	78,309	94,761	13,921	9,817	915

Table G-1 - Crop Production
Missouri Tributaries River Basin, Colorado 1/ (Con't - 3)
(1,000)

County	Year	Corn Silage TNS	Potatoes CWT	Hay TNS	Dry Beans CWT
Adams	1964	79	0	40	5
	1974	66	0	54	8
	1982	62	NA	45	11
Arapahoe	1964	7	0	8	1
	1974	4	NA	24	0
	1982	6	0	9	0
Boulder	1964	114	18	54	14
	1974	60	0	39	16
	1982	77	0	52	30
Clear Cr.	1964	NA	NA	NA	NA
	1974	NA	NA	NA	NA
	1982	NA	NA	NA	NA
Denver	1964	NA	NA	NA	NA
	1974	NA	NA	NA	NA
	1982	NA	NA	NA	NA
Douglas	1964	11	0	13	0
	1974	3	0	16	0
	1982	NA	0	14	0
Elbert	1964	9	0	20	1
	1974	13	0	34	1
	1982	9	0	42	0
Gilpin	1964	NA	NA	NA	NA
	1974	NA	NA	NA	NA
	1982	NA	NA	NA	NA
Jackson	1964	0	0	89	0
	1974	0	0	88	0
	1982	0	0	96	0
Jefferson	1964	1	0	10	0
	1974	2	0	5	0
	1982	NA	0	5	0
Kit Carson	1964	61	0	20	2
	1974	192	NA	40	83
	1982	151	0	44	85
Larimer	1964	230	4	65	55
	1974	310	1	100	59
	1982	316	7	77	99

Table G-1 - Crop Production
Missouri Tributaries River Basin, Colorado 1/ (Con't - 4)
(1,000)

County	Year	Corn Silage TNS	Potatoes CWT	Hay TNS	Dry Beans CWT
Logan	1964	177	3	90	28
	1974	290	0	108	50
	1982	143	0	97	88
Morgan	1964	179	178	90	161
	1974	262	632	100	140
	1982	217	499	79	178
Park	1964	0	0	18	0
	1974	0	0	17	0
	1982	0	0	17	0
Phillips	1964	11	0	16	1
	1974	26	0	28	164
	1982	20	0	14	148
Sedgwick	1964	35	3	26	69
	1974	87	0	20	109
	1982	59	0	14	75
Washington	1964	21	0	44	10
	1974	36	0	54	37
	1982	32	0	34	28
Weld	1964	1,007	1,481	346	525
	1974	1,732	770	351	308
	1982	1,587	1,099	325	499
Yuma	1964	36	0	42	0
	1974	102	37	86	87
	1982	126	0	79	228
Basin	1964	1,978	1,684	991	872
	1974	3,185	1,440	1,164	1,062
	1982	2,805	1,605	1,043	1,469
State	1964	2,400	8,132	2,910	1,488
	1974	3,816	9,872	2,795	1,543
	1982	3,462	14,784	2,736	2,046

Table G-2 - Crop Production-Yield/Acre
Missouri Tributaries River Basin, Colorado 2/

County	Year	WINTER WHEAT Dry Bu	WINTER WHEAT Irr Bu	CORN GRAIN Dry Bu	CORN GRAIN Irr Bu	BARLEY Dry Bu	BARLEY Irr Bu	SORGHUM Dry Bu	SORGHUM Irr Bu	SUGAR BEETS Irr CWT
Adams	1964	12	34	13	76	10	35	15	45	14.7
	1974	24	48	--	100	26	50	--	--	15.3
	1982	27	60	--	115.5	38	59.5	19.5	50	18.5
Arapahoe	1964	12	30	14	70	11	40	10	40	15.2
	1974	17	NA	--	--	28	--	--	--	--
	1982	24	50	--	--	31.5	--	20	--	--
Boulder	1964	15	26	19	71	14	52	15	30	15.4
	1974	25	45	NA	98	30	62	--	--	21.1
	1982	17	44	35.5	130	18	68	--	--	18.6
Clear Creek	1964	--	--	--	--	--	--	--	--	--
	1974	--	--	--	--	--	--	--	--	--
	1982	--	--	--	--	--	--	--	--	--
Denver	1964	--	--	--	--	--	--	--	--	--
	1974	--	--	--	--	--	--	--	--	--
	1982	--	--	--	--	--	--	--	--	--
Douglas	1964	12	32	14	61	9	33	--	10	--
	1974	15	--	--	--	--	--	--	--	--
	1982	32	50	--	--	44	--	--	--	--
Elbert	1964	9	30	14	60	10	34	11	40	--
	1974	20	43	20	75	20	--	--	--	--
	1982	25	50	--	--	36.5	50	16.5	--	--
Gilpin	1964	--	--	--	--	--	--	--	--	--
	1974	--	--	--	--	--	--	--	--	--
	1982	--	--	--	--	--	--	--	--	--
Jackson	1964	23	--	--	--	--	--	--	--	--
	1974	--	--	--	--	--	--	--	--	--
	1982	--	--	--	--	--	--	--	--	--
Jefferson	1964	16	28	17	71	15	39	--	35	--
	1974	25	48	--	--	31	62.5	--	--	--
	1982	18	--	--	--	19	--	--	--	--
Kit Carson	1964	16	32	14	84	13	45	11	45	17.0
	1974	26	48.5	21	102	23	46	12	50	--
	1982	31.5	54.5	40	129	47.5	70.5	26	66	16.7
Larimer	1964	18	33	17	76	13	54	--	36	15.1
	1974	26	52	--	101	33	63	--	--	19.7
	1982	18.5	44	34	126	31	73	--	--	20.8

Table G-2 - Crop Production-Yield/Acre
Missouri Tributaries River Basin, Colorado 2/ (Con't - 2)

County	Year	WINTER WHEAT Dry Bu	WINTER WHEAT Irr Bu	CORN GRAIN Dry Bu	CORN GRAIN Irr Bu	BARLEY Dry Bu	BARLEY Irr Bu	SORGHUM Dry Bu	SORGHUM Irr Bu	SUGAR BEETS Irr CWT
Logan	1964	17	39	19	71	14	41	15	50	16.2
	1974	28	50	16	102	25.5	46.5	--	--	16.9
	1982	26	47.5	47.5	123	30	57.5	27	51	18.6
Morgan	1964	14	40	17	86	11	53	11	52	15.2
	1974	28	54	--	110	29	50	13.5	50	16.8
	1982	25	51	--	132.5	28	59	20	46.5	19.6
Park	1964	--	--	--	--	--	--	--	--	--
	1974	--	--	--	--	--	--	--	--	--
	1982	--	--	--	--	--	--	--	--	--
Phillips	1964	19	33	19	80	15	32	14	50	12.5
	1974	29	48	21	110	--	--	15	60	16.7
	1982	38.5	69.5	55	143.5	46.5	66.5	32	55	18.6
Sedgwick	1964	21	32	20	75	21	46	17	55	17.4
	1974	30	46	17.5	107	27	64	--	--	19.5
	1982	34.5	60.5	57.5	136	27	70	25	47.5	19.6
Washington	1964	13	28	14	82	9	32	12	50	12.9
	1974	30	46	23	103	24	48	14	65	15.7
	1982	28.5	55	44	131	42.5	63.5	26.5	55.5	19.8
Weld	1964	14	32	20	76	14	46	12	55	16.0
	1974	22.5	44	14	108	22.5	62	--	--	19.9
	1982	23	61	34	134	30.5	67.5	33.5	47.5	22.0
Yuma	1964	18	32	14	75	16	32	15	50	15.6
	1974	30	49	20	105	30	46	12	56.5	16.2
	1982	30.5	50.5	35	130	37.5	58	29	59	16.9
State	1964	14.5	33	16	76.8	14	46.9	12.5	44	15.7
	1974	24	47	19	102.5	24	57.5	17.5	54	18.0
	1982	26.5	53	48	131	33	81.0	21	66.5	20.0

Table G-2 - Crop Production-Yield/Acre
Missouri Tributaries River Basin, Colorado 2/ (Con't - 3)

County	Year	CORN SILAGE Irr Tons	POTATOES Irr CWT	ALFALFA AND MIXED HAY Irr Tons	DRY BEANS Dry CWT	DRY BEANS Irr CWT
Adams	1964	14	201	2.8	2.1	18
	1974	17	NA	3.0	--	18
	1982	17	--	3.6	--	13.1
Arapahoe	1964	10	--	2.3	1.8	17
	1974	NA	--	2.5	--	--
	1982	15	--	2.3	--	--
Boulder	1964	14	200	2.4	1.8	17
	1974	17	--	2.8	5	23
	1982	20	--	3.3	--	21.3
Clear Creek	1964	--	--	--	--	--
	1974	--	--	--	--	--
	1982	--	--	--	--	--
Denver	1964	--	--	--	--	--
	1974	--	--	--	--	--
	1982	--	--	--	--	--
Douglas	1964	12	--	2.1	--	--
	1974	NA	--	2.1	--	--
	1982	NA	--	2.1	--	--
Elbert	1964	5	135	1.3	1.6	12
	1974	10	--	1.8	3	--
	1982	13.5	--	1.8	--	--
Gilpin	1964	--	--	1.5	--	--
	1974	--	--	--	--	--
	1982	--	--	--	--	--
Jackson	1964	NA	--	1.5	--	--
	1974	--	--	1.7	--	--
	1982	--	--	1.1	--	--
Jefferson	1964	13	130	1.8	--	17
	1974	16.5	--	1.7	--	--
	1982	15	--	1.7	--	--
Kit Carson	1964	13	--	2.2	2.1	13
	1974	16	--	3.6	3.5	15
	1982	21	--	4.6	--	11
Larimer	1964	16	130	2.6	1.8	17
	1974	19	NA	3.3	4	20
	1982	22.5	--	3.5	--	20

Table G-2 - Crop Production-Yield/Acre
Missouri Tributaries River Basin, Colorado 2/ (Con't - 4)

County	Year	CORN SILAGE Irr Tons	POTATOES Irr CWT	ALFALFA AND MIXED HAY Irr Tons	DRY BEANS Dry CWT	DRY BEANS Irr CWT
Logan	1964	14	190	2.5	1.7	13.5
	1974	18	--	3.4	4	16.8
	1982	19.5	--	4.0	5	15.1
Morgan	1964	16	190	2.4	2.3	16
	1974	19	300	3.5	5.5	18.5
	1982	21	270	4.0	5.0	16.5
Park	1964	--	--	--	--	--
	1974	--	--	--	--	--
	1982	--	--	2.0	--	--
Phillips	1964	8	--	1.2	1.8	15
	1974	16	--	3.6	4	19
	1982	14.5	--	3.9	6	14
Sedgwick	1964	16	175	2.2	1.9	16
	1974	18	--	3.1	6	20
	1982	22	--	3.9	5	13.3
Washington	1964	12	190	2.0	1.8	14
	1974	16	--	2.3	3	17
	1982	18.5	--	2.7	--	14.1
Weld	1964	15	199	2.9	1.9	17.2
	1974	19.5	270	3.6	5.8	18.6
	1982	24	265	4.0	5.0	20.0
Yuma	1964	11	--	2.9	1.8	15.0
	1974	16	NA	3.5	4.6	18.5
	1982	20	--	4.3	4.7	12.6
State	1964	14	199	2.3	3.3	16
	1974	17.5	262	2.7	2.5	18
	1982	21.5	282	3.1	4.7	16

Table G-3 - Livestock Production
Missouri Tributaries River Basin, Colorado 1/

County	Year	Cattle & Calves No.	Milk Cows No.	Hogs & Pigs No.	Sheep & Lambs No.	Chickens No.	Horses No.
Adams	1964	68,839	5,231	19,579	12,548	124,271	NA
	1974	48,284	3,476	26,921	4,088	518,455	871
	1982	51,348	4,319	29,744	NA	4,403	1,449
Arapahoe	1964	19,261	758	543	8,362	48,265	NA
	1974	15,805	638	563	1,257	3,212	621
	1982	11,719	423	944	1,596	2,558	1,567
Boulder	1964	46,227	4,817	3,510	11,074	82,719	NA
	1974	24,555	2,294	2,840	5,850	308,467	1,425
	1982	24,806	2,740	4,607	11,923	496,578	2,604
Clear Cr.	1964	NA	NA	NA	NA	NA	NA
	1974	NA	NA	NA	NA	NA	NA
	1982	NA	NA	NA	NA	NA	NA
Denver	1964	3	1	0	0	61,967	0
	1974	NA	NA	NA	NA	NA	NA
	1982	129	0	0	0	0	169
Douglas	1964	23,600	1,349	1,899	176	16,770	NA
	1974	16,663	518	166	359	1,617	1,250
	1982	15,402	133	350	744	3,523	2,920
Elbert	1964	50,939	2,301	1,295	6,537	36,733	NA
	1974	53,901	1,279	5,006	243	44,026	1,003
	1982	56,274	1,511	2,858	1,844	3,494	1,694
Gilpin	1964	238	7	1	1	70	NA
	1974	NA	NA	NA	NA	NA	NA
	1982	169	0	0	0	0	0
Jackson	1964	38,606	198	32	5,040	498	NA
	1974	40,412	70	NA	3,748	316	864
	1982	42,380	57	14	321	255	1,307
Jefferson	1964	10,881	1,518	1,038	6,032	23,640	NA
	1974	6,624	811	189	33	5,545	1,470
	1982	5,561	318	526	394	3,328	2,785
Kit Carson	1964	66,519	1,454	5,545	4,409	18,342	NA
	1974	135,959	1,835	6,684	3,077	6,560	482
	1982	116,418	1,538	11,340	1,219	3,693	654
Larimer	1964	87,184	8,463	6,069	89,345	69,882	NA
	1974	83,700	6,619	18,243	82,217	35,976	1,816
	1982	87,033	6,751	12,616	29,407	26,297	3,186

County	Year	Cattle & Calves No.	Milk Cows No.	Hogs & Pigs No.	Sheep & Lambs No.	Chickens No.	Horses No.
Logan	1964	143,332	1,698	6,558	5,781	30,413	NA
	1974	159,498	1,204	24,627	2,451	6,175	671
	1982	128,113	792	28,586	3,372	2,583	842
Morgan	1964	156,134	3,672	16,444	20,113	34,151	NA
	1974	150,927	3,910	43,964	1,033	58,055	707
	1982	139,166	3,987	56,559	1,898	2,091	696
Park	1964	20,910	52	13	16,735	621	NA
	1974	16,177	24	10	158	557	383
	1982	10,578	20	36	727	721	802
Phillips	1964	21,373	617	4,595	8,097	17,301	NA
	1974	33,170	788	5,186	2,890	3,443	208
	1982	39,925	882	4,452	2,625	1,677	225
Sedgwick	1964	29,945	157	2,071	1,239	12,619	NA
	1974	32,637	97	1,750	19	2,023	255
	1982	30,047	59	1,273	486	504	268
Washington	1964	59,918	1,498	6,259	8,449	27,669	NA
	1974	72,538	1,022	13,811	1,390	8,311	634
	1982	76,217	349	16,180	1,544	3,118	995
Weld	1964	393,353	25,523	14,575	199,957	157,651	NA
	1974	605,720	22,349	31,859	256,072	1,092,412	2,984
	1982	576,376	29,083	51,087	188,022	1,375,188	4,464
Yuma	1964	88,225	2,013	9,422	4,122	28,988	NA
	1974	136,755	2,300	8,778	3,760	6,441	629
	1982	151,769	3,126	24,661	2,771	3,232	1,005
Basin	1964	1,325,487	61,327	99,467	408,016	792,571	NA
	1974	1,633,325	49,234	190,597	368,645	2,101,591	16,273
	1982	1,563,430	56,088	245,833	248,893	1,933,243	27,694
State	1964	2,499,246	92,731	169,759	1,482,068	1,279,502	NA
	1974	3,087,884	71,353	291,342	985,019	2,253,086	45,227
	1982	2,945,922	76,882	333,370	742,070	2,566,660	72,182

1/ Source: Colorado Census of Agriculture 1964, 1974, 1982, Bureau of Census, Department of Commerce.

2/ Source: Colorado Agricultural Statistics for 1964, 1974 and 1982. Data published by Colorado Department of Agriculture, cooperating with USDA Statistical Reporting Service, statistical information by Colorado Crop and Livestock Reporting Service.

APPENDIX H

IRRIGATION: POTENTIAL FOR PLANNING AND IMPLEMENTING A WATER CONSERVATION PROGRAM BY MAKING IRRIGATION IMPROVEMENTS 1/

Colorado Worksheet

Water District, SCD and Field Office ________ / ________ / ________
Name of Ditch System ______________________ : ____________ Acres; ____________ # of Farms

Factors	Rating	Score	High	Moderate	Low
WATER QUANTITY	(Low-High)		(Circle the criteria appoximating the level; if applicable.)		
1. Reduce Ground Water Mining	0-3	___	100%	50%	None
2. Increase Farm Water Supply	0-3	___	Develop surpluses	Eliminate shortages	No change
3. Reduce Diversions	0-3	___	>50%	30%	<10%
4. Reduce Return Flow	0-3	___	>50%	30%	<10%
5. Improve Efficiency: a. Conveyance	0-4	___	>30%	20%	<10%
b. Onfarm	0-4	___	>20%	10%	< 5%
Subtotal	20	___			

Effects 2/ ______________________________

Factors	Rating	Score	High	Moderate	Low
ECONOMICS					
1. Increase in Gross Value in Agriculture	0-7	___	>$125 gross/AC	$75 gross/AC	<$25 gross/AC
2. Decrease in Cost of Production	0-3	___	Significant	Some potential	No potential
3. Operation and Maintenance	0-3	___	Significant reduction	Some reduction	No reduction
4. Increase Productivity:					
a. Water Shortage	0-2	___	Treatable (optimum)	Some yield increase	No potential
b. Soil Salinity	0-2	___	Treatable (optimum)	Some yield increase	No potential
c. Water Logging	0-2	___	Treatable (optimum)	Some yield increase	No potential
5. Marketability of Water Conserved	0-1	___	Easily sold (>$1000)	No sale, but used	No sale, surplus
Subtotal	20	___			

Effects 2/ ______________________________

Factors	Rating	Score	High	Moderate	Low
ENVIRONMENTAL					
1. Water Quality: a. Salinity	0-3	___	Treatable(significant)	Some potential	No potential
b. Sediment	0-3	___	Treatable(significant)	Some potential	No potential
c. Nutrients and Pesticides	0-3	___	Treatable(significant)	Some potential	No potential
2. Wetlands - Wildlife	0-2	___	Few effects	Some change	Loss valuable habitat
3. Instream Flow	0-2	___	Significant improvement	No change	Reduced flow
4. Erosion	0-2	___	>3 ton/Ac reduction potential	2 ton/AC reduction	No change
Subtotal	15	___			

Effects 2/ ______________________________

Factors	Rating	Score	High	Moderate	Low
SOCIAL EFFECTS					
1. Energy Use	0-5	___	Savings	No change	Increase use
2. Windfall benefits	0-3	___	<$100,000/farmer(all)	Some over $100,000	Many over $100,000
3. Loss of Prime Land	0-3	___	High value	Low value	No change
4. Impact on Existing Uses	0-3	___	Change to high value	Some improvement	No impact
5. Life, Health, Safety	0-1	___	Reduces hazard	Some improvement	No impact
Subtotal	15	___			

Effects 2/ ______________________________

1/ Insert additional comments on back. Include a map with ditches drawn on it.
2/ What are the significant results from treating the above factors?
3/ Include other potential purposes like: flood, recreation, M&I, Energy, Erosion, F&WL, other.

-continued-

Factors	Rating	Score	High	Moderate	Low
LEGAL & INSTITUTIONAL	(Low-High)		(Circle the criteria approximating the level; if applicable.)		
1. Advocate of Beneficial Use - Conservation, Salvage	0-5	___	No conflicts	Neutral	Many problems
2. Ground Water/Surface Water Law	0-3	___	Strong law	Neutral	No law
3. Loss of Water to Other Uses	0-2	___	No conflict	Neutral	Problems
Subtotal	10	___			

Effects 2/ ____________________

Factors	Rating	Score	High	Moderate	Low
IMPLEMENTATION POTENTIAL					
1. Acceptability: a. Local	0-5	___	Active support	Supportable	Opposition
b. National	0-3	___	Fits USDA program	Supportable	Requires new program
2. Technical Assistance	0-3	___	<4 man-years	<8 man-years	>10 man-years
3. Capital Cost: a. conveyance	0-2	___	<$250/Ac	<$500/Ac	>$1000/Ac
b. Onfarm	0-3	___	<$250/Ac	<$500/Ac	>$1000/Ac
4. Financial Incentatives, Federal & State	0-2	___	<$ 1 million	<$5 million	>$10 million
5. Time to Plan and Design	0-2	___	<1 year	<2 years	>5 years
Subtotal	20	___			

Effects 2/ ____________________

TOTAL ______ (100 Possible) Bonus Points: ____________________

Magnitude Problem: ____________________

____

Viable Solutions: ____________________

Additional Impacts 3/: ____________________

Rehabilitation Needs of System:	Insert Significant, Moderate, Or Little
1. Canal Lining on Pipeline	
2. Replace Conveyance System Water Control Structures (WCS)	___
3. Replace Onfarm WCS	___
4. Land Leveling	___
5. Onfarm Ditch Lining or Pipeline	___
6. Irrigation Water Management	___
7. Does the system have reservoir storage (yes or no). Reservoir improvement needed.	___

1/ Insert additional comments on back. Include a map with ditches drawn on it.
2/ What are the significant results from treating the above factors?
3/ Include other potential purposes like: flood, recreation, M&I, Energy, Erosion, F&WL, other.

GUIDELINES FOR COMPLETING THE EVALUATION WORKSHEET

POTENTIAL FOR PLANNING AND IMPLEMENTING A WATER CONSERVATION PROGRAM BY MAKING IRRIGATION IMPROVEMENTS

GENERAL

1. A high score would indicate that a very critical problem would be addressed, solutions appear to be cost effective, the environment would not be harmed, and the local people are able and willing to move with implementation of a program.

2. Estimate numerical values.

0-1	High (1)	Moderate (.5)	Low (0)
0-7	High (7)	Moderate (4)	Low (1)

3. Insert a zero for a very low or negative impact, and a N/A for factors which are not applicable in the area.

4. If a high rating is given for a problem factor contrary to the rating scale, footnote your logic. There will be some exceptions.

WATER QUANTITY FACTORS

1. If a conservation program will reduce withdrawals and extend the life of the ground water aquifer, apply a high rating. However, if the ground water will be exhausted in the "very near" future, rate it a zero.

2. Apply a high rating if the conservation program will increase water supplies. A surplus applies only to water short areas with limited supplies.

3. Apply a high rating if diversion requirements are reduced a significant amount over 50 percent or maybe in volume (100,000 AF may be only 20% but is a lot of valuable water).

4. Apply a high rating if a significant reduction in return flow.

5. Efficiency defined as: Conveyance - The volume of water delivered to the farm, expressed as a percent of the volume of water diverted. Onfarm - The volume of water stored in the soil root zone and used by the crop, expressed as a percent of the volume of water delivered to the farm.

ECONOMICS FACTORS

1. The value of water is expressed in terms of the gross value of production from an acre. High > \$125.00; Moderate \$75.00; < Low \$25.00. However, the cost to the farmer of water delivery usually does not reflect its true value.

2. Reduced irrigation labor, water cost, fertilizer, energy use, etc., should be considered.

3. Rate high if there will be a significant OM&R cost reduction.

4. Rate high if a viable water conservation program to improve returns to the farmer by minimized water shortages, and reduced salinity and water logging.

5. Rate high an area where conserved water can be put to beneficial use.

ENVIRONMENTAL FACTORS

1. Determine if a water conservation program will reduce the sediment, salinity, or nutrient contribution to downstream users or ground water; but rate it high only if a reduction will impact a water user, such as municipal, domestic, fisheries, recreationists, etc.

2. Determine the degree which the program will effect wetlands and wildlife.

3. If the conservation program improves instream flow for important fisheries, etc., note it high.

4. If serious erosion (> "t" value) can be reduced by irrigation water management, rate this factor high.

SOCIAL FACTORS

1. Apply a high rating if energy use can be reduced. Generally, in areas with significant pumping.

2. Apply a high rating if no windfall benefits (no farmer receiving > $100,000) occurs.

3. Rate high if the water conservation program will assist farmers maintain a viable enterprise and preserve prime or important land.

4. Rate high if the program would result in enhanced use of the irrigation resource and benefit the farmer or rancher.

5. Add a point if a life, health, or safety hazard is reduced.

LEGAL AND INSTITUTIONAL FACTORS

1. Rate high if state law is a strong advocate of beneficial use and the legislation or courts rule in favor of conservation or salvage. For example, the new Arizona ground water law (conservation) is a plus. The "use it or lose it" attitude in some headwater areas would rate low.

2. Heavy state involvement in administering surface or ground water law. For example, requiring water measurement on pumps in closed ground water basin.

3. Agriculture has a problem if water is being transferred to other uses. High rating, if most of the water will stay in agricultural use.

IMPLEMENTATION POTENTIAL FACTORS

1. Rate high if there is strong local support or it can be generated and if the treatment can be accomplished with existing viable USDA programs.

2. Rate high if the area can be given high priority for technical assistance with an adequate number of personnel.

3. Lower unit capital cost for improvements would be given higher priority for funding.

4. Rate high if the federal or state cost share for a unit is less than $1 million. Easier to obtain approval.

5. Rate high if planning can lead to implementation in a reasonably short time. Complex units with several different agency's objectives would rate low.

OTHER CONSIDERATIONS

Bonus Points - Define the factor:

For example:
1. Substantial state or local participation in planning.
2. Inventories readily available.
3. Existing analytical models being used for evaluation.
4. Can be implemented by a viable USDA program.
5. The state has a grant and loan program for irrigation.
6. Others.

Effects - Identify the key objectives

Water conservation: To reduce salinity; to increase crop production; to reduce costs; to salvage water; to reduce the rate of ground-water mining; to prevent salt-water intrusion; to renovate old and obsolete systems; to increase profits; to administer a law; etc.

Magnitude of the Problem: Quantify - For example: Loss of production on 10,000 acres; mining will exhaust the ground water in 10 years. Each irrigated acre produces 10 tons of salt and each ton does $50 in annual damage. Excessive erosion (6-12 tons/acre) on 10,000 acres. The delivery system is not dependable.

Viable Solution: The primary considerations are the physical, economical, legal and institutional, environmental, and social suitability of water conservation to solve the problem. For example: Physical solution to solve water shortage is lateral rehabilitation, with economic questions to be answered.

Additional Impacts: Quantify - For example: Implementation of water conservation program should eliminate water shortages on 5,000 acres, stabilize the economy, and may result in positive net benefits. An obsolete irrigation system will be replaced and a viable irrigated agricultural base will be maintained for 100 farmers. Erosion on 23,000 acres will be minimized and production capability will be preserved for future generations. Also include other potential purposes. For example: If flood protection is needed, it may be a plus if it goes in concurrently, or a negative, if it is required before water conservation can be accomplished.

Rehabilitation Needs of System:

Indicate the degree for the various rehabilitation needs.

APPENDIX I

MISSOURI RIVER BASIN MODEL

"IPES"

IRRIGATION PROJECT EVALUATION

SYSTEM

ABSTRACT

The Irrigation Project Evaluation System is a system of computer programs designed to evaluate and compare the economic effects of alternative small and medium scale irrigation projects. The method used is to compare amortized costs of the various project alternatives with their yearly benefits as calculated with a Linear Programming system.

GENERAL SYSTEM DESCRIPTION

The irrigation Project Evaluation System (IPES) was developed as a result of the need to evaluate and compare the economic effects of alternative water projects on particular irrigation canal systems.

The Economic Research Service (ERS) was the lead agency in providing the computer programming for IPES. IPES was made operational by ERS at the Fort Collins Computer Center (FCCC).

IPES was used to analyze canal systems which contain a surface water supply and serve two or more water users. Evaluations were made for each canal system as follows: 1) the base or future without project situation; 2) that base situation -- with allowances for crop acreage shifts; 3) management improvements; 4) various combinations of management plus structural improvements.

The Problem

Numerous irrigation systems in Colorado are in a run-down condition and/or operating inefficiently. Is it economically feasible to make improvements, and if so what types of improvements would be most cost effective?

A method was needed which would evaluate the future without improvements and allow a comparison to situations in which projects under consideration were assumed completed.

The Analysis

The IPES Model is a system that includes: 1) programs to develop a data matrix suitable for linear programming analysis; 2) linear program analysis (LP analysis); 3) programs to interpret the linear program output and generate a report.

The basic constraints in the model are water and land. A water budget is necessary to analyze the water supply and provide data for the LP matrix.

Land data (acres) is provided as input in terms of various crops. The physical irrigation system, potential crop yields, and project improvement alternatives are also provided as input. More details follow on the water budget analysis and linear program analysis.

WATER BUDGET

The water budget analysis in the model is designed to use actual monthly diversions, reservoir water, and pump water as the water supply to crops served by a canal system. A conveyance system efficiency is applied to diverted and reservoir water to allow for seepage losses. An onfarm irrigation efficiency is applied to that diverted water and reservoir water reaching the farm and to onfarm pump water. The results of these computations is an amount of water available for consumptive use (CU) by the crops.

The Soil Conservation Service Technical Release 21 is used to determine consumptive irrigation requirements (CIR) for those crops served by the canal. This is the amount of water required to meet full needs of the crops.

The water available for consumptive use is compared to CIR, and actual consumptive use is determined. The actual CU is either the CIR when adequate water is available, or the amount of water available for CU when adequate water is not available.

The comparison of water available for CU to CIR, previously discussed, is also used to determine water surplus or deficit.

Seepage losses in the conveyance system, and onfarm losses, are distributed to surface return flows or groundwater recharge in accordance with return flow percentages given in the basic input data. During those months when surplus water is available, up to 0.3 acre-foot per acre of soil moisture is carried over to the following month. This feature more closely resembles actual field conditions and does cause higher CU and lower return flow values.

Salt in return flows and groundwater recharge is computed by applying total dissolved salt coefficients given in the basic input to return flows previously discussed.

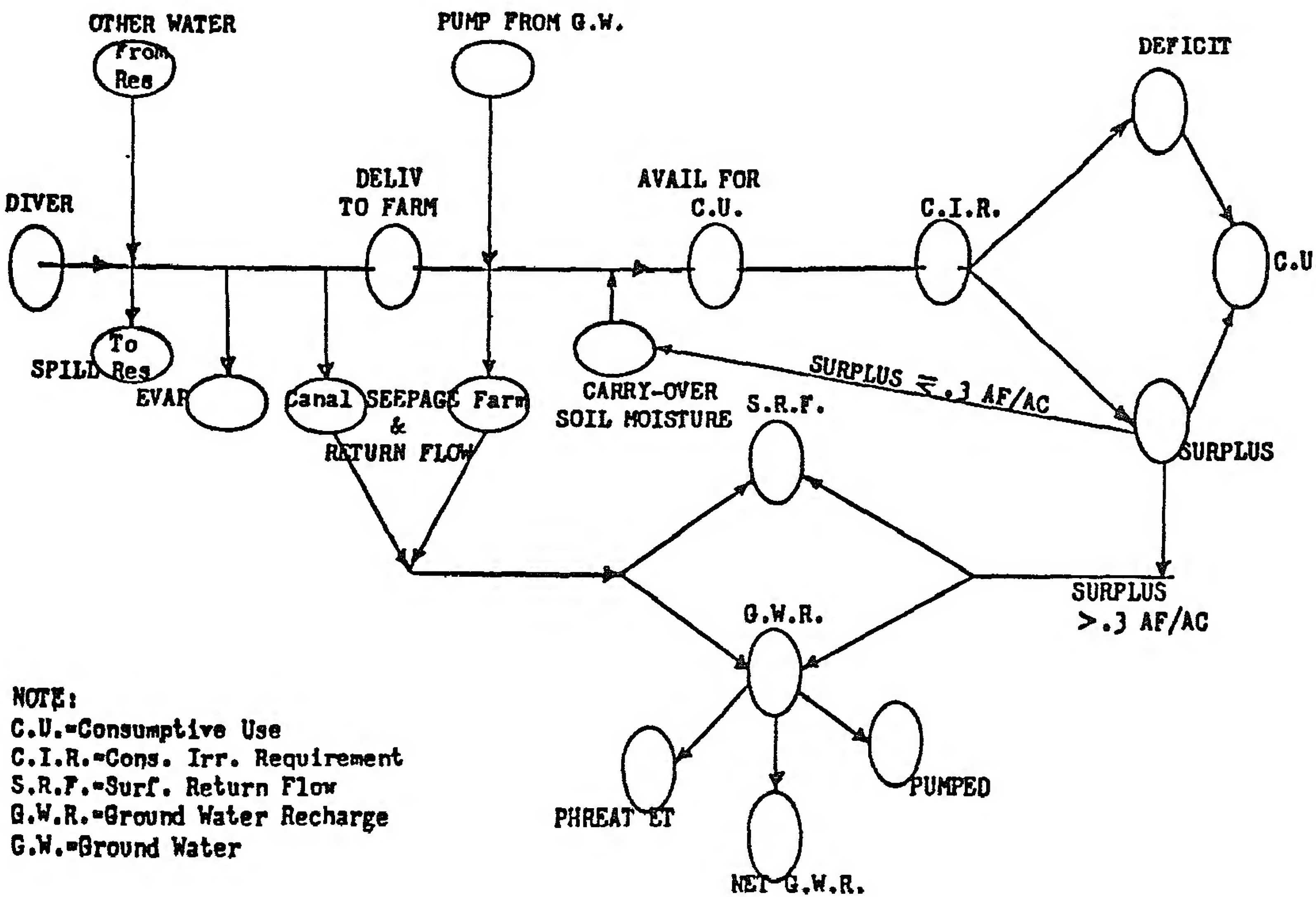
Other computations included in the model are evapotranspiration by phreatophytes and wetlands, and evaporation from reservoirs in the system.

Reservoir (other water) and pump water are handled somewhat differently than diverted water. Reservoir water is given as a season total. This is brought into the analysis only as shortages from diverted water occur, and to the extent needed until depleted. This process also applies to pump water.

The water budget is an integral part of a linear program (LP) and report writer model. The water budget scheme develops water supply information required by the LP. The LP then evaluates numerous alternative soil-water-net return combinations and selects the most economically beneficial one within the limits of available land and water. One feature of the LP includes allowing the number of acres irrigated and the crop distribution to shift within prescribed limits. One such set of bounds is that of allowing the number of acres of any crop to shift down no more than 40 percent or shift up no more than 10 percent from present conditions. All alternatives have this possible fluctuation available except the initial condition. It is not uncommon for the model to select a situation of reduced acres irrigated for a given short water supply as providing the greatest net return to the irrigator. Another common solution might be a shift in cropping pattern to more cost-effective crops.

The reason for discussing the LP characteristics here is because of possible fluctuations in acres irrigated, and cropping patterns for various alternative solutions. This has a bearing on consumptive use, surplus, shortage, and return flow values computed in the water budget analysis. Therefore, when comparing water accounting information for various alternatives within a run, the number of acres irrigated and the crop distribution should be noted because of their effect on water use.

WATER BUDGET



NOTE:
C.U.=Consumptive Use
C.I.R.=Cons. Irr. Requirement
S.R.F.=Surf. Return Flow
G.W.R.=Ground Water Recharge
G.W.=Ground Water

THE LINEAR PROGRAM ANALYSIS

A linear program (LP) is a useful analytical tool. A linear programming problem is a problem in which it is desired to maximize or minimize a linear function, called the objective function, of several unknowns x(1), x(2), ..., called activities, subject to linear constraints on the unknowns. A linear function is a function of the form:

$$f(\ x(1),\ x(2),\ \ldots\ x(n)\ ) = c(1)*x(1) + c(2)*x(2) + \ldots\ c(n)*x(n)$$ 1/

A linear constraint is a constraint of the form:

$$a(i,1)*x(1) + a(i,2)*x(2) + \ldots\ a(i,n)*x(n) \leqq b(i)$$

or:

$$a(i,1)*x(1) + a(i,2)*x(2) + \ldots\ a(i,n)*x(n) \geqq b(i)$$

where the a(i,j)'s are constants.

--Example of an LP Problem

In a certain geographical area let:

x(1) = the acres of corn to be planted.

x(2) = the acres of wheat to be planted.

x(3) = the acres of barley to be planted.

c(1) = the net return for one acre of corn.

c(2) = the net return for one acre of wheat.

c(3) = the net return for one acre of barley.

So our objective is to maximize the function:

$$f(\ x(1),\ x(2),\ x(3)\ ) = c(1)*x(1) + c(2)*x(2) + c(3)*x(3)$$

by choosing values for the x(j) which make f as large as possible.

1/ The * means multiplied by.

Reality forces us to place certain constraints upon this problem. The total land available is limited, we suppose it to be equal to b(1).

The we must have the condition:

$$x(1) + x(2) + x(3) \leqq b(1)$$

which is the same as:

$$a(1,1)*x(1) + a(1,2)*x(2) + a(1,3)*x(3) \leqq b(1)$$

while:

$$a(1,1) + a(1,2) + a(1,3) = 1$$

to match our original formulation.

If this is the only constraint it is easy to find the solution, just find the most profitable crop and plant all of the land with that crop, i.e., find the largest positive c(j) (suppose it is c(2), then let x(2) = b(1) and x(1) = x(3) = 0). So f has the maximum value:

$$f = c(2)*x(2) = c(2)*b(1).$$

Other constraints are necessary. Suppose the total water supply is limited to b(2). Suppose corn requires a certain amount of water per acre, say a(2,1) acre feet, and say a(2,2) acre feet for wheat and a(2,3) acre feet for barley. Then we must require that:

$$a(2,1)*x(1) + a(2,2)*x(2) + a(2,3)*x(3) \leqq b(2).$$

At this point the solution begins to be less obvious since the most profitable crop may take a prohibitive amount of water.

(end of example)

In this system the function f we are maximizing is the farm net return of a particular area. The unknowns x(j) are acreages of particular crops grown on particular soil types with full or partial water supply. The c(j)'s are the returns or cost associated with the activities x(j). The constraints on the unknowns include constraints on the land available for cropping on different soils, the water available, both surface and ground, and constraints on the acreage distributions themselves. a(i,j) is the consumption rate for the <u>jth</u> activity consuming the <u>ith</u> resource. b(i) is the amount of the <u>ith</u> resource available.

DATA FILES

Input data is supplied in 2 categories; 1) reach data, 2) canal system data. The reach data is crop yield-net return type information, crop consumptive use data, and other physical information that does not change significantly from canal to canal. The canal system data is physical information for a specific canal system and associated cropland. Several canal system data files can be associated with the same reach data file. Each canal system file can include data for the future without project condition and two alternative conditions.

This data was collected by interviews with Irrigation Company Officials, from local SCS Field Offices, and from maps and other references available.

THE REPORT WRITER

The Missouri River Basin Model "IPES" writeup should be used for information on the methodology involved in producing this report writer output.

A report was developed for each irrigation canal system through a report writer program within the "IPES" model. Information for the report writer came either from the canal system inventory directly or from the linear programming (LP) output. The LP analysis used canal system inventory data.

The report writer reports consisted of 4 columns of data for each run. The first column of data depicted the FWOP (future without project) situation. The second column depicted data where the LP solution was allowed a 10% upward and 40% downward shift in cropping pattern. This was done because the project alternatives were also allowed a 10% upward and 40% downward shift in cropping pattern, therefore, the FWOP condition run (allowing the 10% and 40% shifts) was used to make comparisons with project alternatives.

The next two columns depicted data for two different levels of project action as discussed in the Method of Analysis part of the IPES model writeup.

The depicted data consisted of the following categories:

1. land use
2. projects
3. costs
4. benefits
5. production values
6. yields
7. hydrologic data

The land use data consisted of acreages by soil association, acreages by crop, acreages with a full water supply, a partial water supply, wetland, cottonwood land, phreatophyte land and prime land.

The project information included construction cost per acre, mile, or structure; total construction cost; installation cost (construction cost + 31% to cover administration and engineering); and annual installation cost (installation cost amortized for 25 years at 8 5/8% interest); and annual O&M cost.

The engineering practices included canal cleaning, canal lining, canal pipelines, diversion structures, canal water control structures, farm ditch lining, farm pipelines, and farm water control structures. Non-structural measures included land leveling, on-farm drainage, reservoir improvement, irrigation water management, conversion of irrigation method, conservation cropping, phreatophyte eradication, cottonwood eradication, wetland eradication, uplands habitat management, and wetland habitat management.

The 31% for engineering and administration and the annual O&M costs were not added to the last five of these. The total cost was amortized at 8 5/8% for 25 years. The costs for all included practices were added to give total construction, installation, annual, and O&M costs for each alternative.

The first set of benefits listed was annual crop production benefits. These were derived by taking the difference in the net returns from the FWOP condition LP run and each of the alternative runs. The next line in the benefit section listed annual net benefits which were the differences between annual project benefits and the sum of the total annual installation and O&M costs. Major project benefits consist of reduced costs of production such as labor, water costs, pumping and O&M as well as benefits from reduced water shortages such as yield increases and conversion of cropland to higher income crops. Many of the net returns were negative because of high construction costs. The next line is a benefit costs ratio.

The following set of rows pertain to production values. The first row of the set displayed total value of crop production. This was the sum of the gross returns of all the crops which entered a particular solution. The value of production or gross returns by individual crop was listed next. The last item listed in this set was the net returns from irrigated crop and pasture production. The net returns were obtained directly from the LP solution.

The next set of data displayed average crop yields by crop. These yields were weighted by the acres in full water supply and the various combinations of water shortages and yields associated with the shortages.

The final set of data dealt with the hydrologic or water and salt loading accounting. The first group of rows under this set dealt with acre-feet of water diversions by month, April through October. Following this was spill water or water withdrawn to reservoirs by month, April through October. The next line was seasonal evaporation from reservoirs. This was determined by applying an acre-feet/acre coefficient to the surface area of the given reservoirs. The coefficient was found in the reach section of the canal system inventory. Following this was other water which included reservoir and purchased water, for the season. The next line listed conveyance efficiency in percent. All of the above lines within the canal system inventory.

The next line depicted canal seepage which was equal to acre-feet diverted x 1/ (1.00 - 2/ conveyance efficiency in decimal form) + other water x (1.00 - conveyance efficiency in decimal form). The next two lines depicted the percent of canal seepage which went to groundwater and to surface return flows.

Following this was a line with surface water delivered to farm. It consisted of divert - spills - evaporation x conveyance efficiency + other water x conveyance efficiency. The next data set depicted groundwater pumped and was taken directly from the canal system inventory. The next line displayed total water at the farms; this was the combined value of surface wate delivered to the farm and pump water at the farm. The next line was the on-farm efficiency in percent which came directly from the canal system inventory.

The monthly water situation was the next listing. Irrigation water can be either a surplus or deficit to crop requirements for the irrigation months of April through October. The monthly calculations and season totals were obtained directly from the model solution. For details of the water use analysis, see the water budget part of the IPES model writeup.

Crop consumptive use comprised the next line. This was calculated by multiplying crop acres by soil association by the approximate full or short CIR values for months where water was required. Next came surface return flows from farm. This was calculated by total water at the farm x (1 - field efficiency) x percent of farm water losses to surface return flows. Percolation to groundwater at the farm was next. This was calculated by total water at the farm x (1 - field efficiency) x percent of farm water losses to groundwater recharge. The next line was phreatophyte, wetland, and cottonwood uses of groundwater. These values were calculated by the acres within these categories x factors found in the reach data section of the canal system inventories. Following these were the net gain or loss to groundwater. This was calculated as groundwater recharge from the canal systems plus groundwater recharge from the farm less groundwater pumped - phreatophyte ET. The next line was total surface water return flow. This was the sum of canal water and farm water to surface return flows.

The final set of data involved salt in surface return flow, salt in groundwater recharge, salt in pump water, and net salt to groundwater. These values were determined by applying salt loading coefficients found in the canal systems inventory to the acre-feet of water found in these various categories.

1/ - refers to subtraction sign.

2/ x refers to multiplication sign.

METHOD OF ANALYSIS

Project benefits are handled in the model in two ways. The first is increased crop yields from a reduction in water shortages. The second is increased yields from improved management. The water supply change in the model is made through improving irrigation efficiencies or the supply itself. The management affect is applied through the use of crop yield indexes as well as through increased on-farm irrigation efficiencies included in alternative data. Two alternatives can be analysed in each run along with the future-without-project condition.

Crop yields shown in the canal inventory data reflect future-without-project conditions which is essentially present management levels with no short water restrictions. The model automatically reduces these yields to reflect effects of water shortages. The yields are considered an average (by crop) of all acres under the canal system. This includes those acres that presently have proper irrigation water management along with those acres that do not. This assumption was made because of insufficient data to estimate a percent of cropland that presently has proper irrigation water management. Crop yields shown in the alternative data follow the same assumption except the level of management and yields would be higher as a result of an assumption that all acres will have proper irrigation water management (for those alternatives that include irrigation water management).

The model was initially run for a future-without-project condition accompanied by an irrigation water management alternative (Alt 1) and the canal company alternative (Alt 2). The canal company alternative included irrigation water management as well as those structural measures identified as needed by the irrigation company.

Irrigation water management practices and associated costs were applied to all crop acres under the system for alternatives 1 and 2. The costs associated with the practice is assumed an average cost which includes applying water management to those remaining acres needing it and no cost on those acres already properly managed. The average cost used in the model is a lump sum value. The model amortizes this over the project life to produce an average annual cost of about $6.00 per acre. Other project costs are handled in a similar fashion.

Alternative 2 was modified to more closely match conveyance system lining to the lengths of canal in a high seepage category. This is considered Alternative 2M. Alternative 3 included needed structural measures, as defined in alternative 2 or 2M (whichever produces greater net returns) for the off-farm conveyance system and no on-farm improvements (irrigation water management not included). Alternative 4 included needed on-farm structural measures (irrigation water management not included), as defined in alternative 2 or 2M, but no off-farm conveyance system improvements.

When diversion or reservoir structures were included as part of an alternative, water supply values were adjusted. The future-without-project condition showed a reduced water supply to reflect a loss of the irrigation facility. The alternative data restored the water supply in accordance with the level of improvement applied. The model responded to the restored water supply with greater crop yields which provided project benefits. Benefits from other structural measures were generated from improved conveyance or on-farm irrigation efficiencies which in turn, provided more water for crop consumptive use, and increased crop yields.

On-farm and conveyance system efficiencies were computed by a set of equations that apply to future-without-project as well as for alternative conditions. The equations were used for the purpose of consistency. Fertilizer, O&M, labor and all other production costs have been included in crop budgets separate from this model. These crop budgets provided net return data that is included as reach data in this model. Therefore the fertilizer and labor records contain zero cost.

APPENDIX J

- SAMPLE -

LARIMER COUNTY CANAL

LARIMER - WELD COUNTIES COLORADO

MISSOURI RIVER TRIBUTARIES COLORADO

COOPERATIVE RIVER BASIN STUDY

1986

I. Introduction

The Colorado Water Conservation Board, acting for the State of Colorado, requested the Department of Agriculture to conduct a cooperative river basin study of the Missouri River Tributaries of Colorado. This included the North and South Platte River basins along with the Republican River Basin.

The Board's request stemmed from its legislative authority, which charges the Board with these responsibilities: (1) to promote the conservation of the waters of the State of Colorado in order to secure the greatest utilization of such waters and the utmost prevention of floods, and (2) to cooperate with the United States and agencies thereof, and with other states, for the purpose of bringing about the greatest utilization of the waters of the State of Colorado and the prevention of flood damages.

Data developed by this study will enable farmers and irrigation companies, with USDA and state assistance, to improve their productivity, water use efficiency, and water management. As a result, the social, environmental and economic stability of the area should be improved. Cooperating agencies of the U.S. Department of Agriculture included the Economic Research Service, the Forest Service, and the Soil Conservation Service. Participation in the study was under the authority of Section 6, Public Law 83-566, as amended. The Colorado Water Conservation Board was also an active participant in the study. It indicated that, while many problems related to water resources exist in the basin, individual systems planning is the most critical need not already studied by other agencies or groups.

Therefore, this cooperative study addressed the water resources problems found in individual irrigation systems. Twenty-six canal systems were selected for detailed analysis in an irrigation model. These systems were intended to be representative of systems in the South Platte River Basin in Colorado. Alternatives were developed that would promote water conservation, water use efficiency, water management, and improved productivity on irrigated cropland under the selected canal systems. These data will be expanded to estimate possible improvement needs and effects of improvement installations basinwide.

II. Description

The Larimer County Canal is located in Larimer and Weld Counties, Colorado. It serves 49,892 acres of irrigated cropland in these counties. The water source is northwest of Fort Collins, Colorado on the Cache la Poudre River. It carries direct diversions, along with water for storage in 11 reservoirs. The canal is approximately 66 miles long. The needs of the canal system include minor improvements on 10 reservoirs, canal lining, and cleaning. The onfarm needs include water-control structures, ditch lining, farm pipelines, land leveling, irrigation water management, and change in irrigation method.

III. Possible Alternatives

The alternative plans for canal systems and onfarm improvements were composed of various combinations and amounts of the following elements: canal lining, canal pipelines, diversion structures, water-control structures, reservoir modifications, weed and phreatophyte control along ditches, onfarm ditch lining, onfarm pipelines, land leveling, drainage, changes in irrigation methods, and irrigation water management. Plans ranging from primarily management only, to total needed treatment, with intermediate level increments, were developed for each system studied. Each alternative plan was evaluated to determine its impacts on water supplies--both surface and ground--water quality, and change in land use or cropping patterns.

A computer program (Irrigation Project Evaluation System) was developed to evaluate and compare the economic effects of each alternative. The method used compares amortized cost of the various alternatives with their yearly benefits. Description of computer programs located in Appendix I.

The alternatives considered for Larimer County are:

FWOP	Future Without Project
FWOP #2	FWOP with set bounds - no more than 40 percent down and/or 10 percent up on acres of any crop.
Alternative #1	Irrigation water management
Alternative #2	Canal Company Alternative - Irrigation water management with irrigation company structural measures along with onfarm needs.
Alternative #2M	Same as Alternative #2 except the conveyance systems lining lengths were modified to match the high seepage portions of the canal.
Alternative #3	Off-farm canal conveyance system structural needs. Irrigation water management not included.
Alternative #4	Onfarm structural needs. Irrigation water management not included.

Alternative #2 has the greater net benefits of any structural alternative for Larimer County.

IV
MODEL OUTPUT

MISSOURI TRIBUTARIES COOPERATIVE RIVER BASIN STUDY
SYSTEM NAME -- LARIMER COUNTY
LOCATION -- LARIMER
BASIN -- CACHE LA POUDRE

LAND USE IN SYSTEM BY ACRES		FWOP	FWOP#2	ALT#1	ALT#2	ALT#2M	ALT#3	ALT#4		
ACRES IN SYSTEM BY SOIL										
SOIL ASSOCIATION 071	AC	49892	49892	49892	49892	49892	49892	49892	0	
TOTAL	AC	49892	49892	49892	49892	49892	49892	49892	0	
ACRES IN SYSTEM BY CROP										
ALFALFA	AC	16000	17600	17600	17600	17600	17600	17600	0	
CORN	AC	23892	26281	26281	26281	26281	26281	26281	0	
PASTURE	AC	10000	6011	6011	6011	6011	6011	6011	0	
FULL WATER SUPPLY	AC	23892	26281	26281	26281	26281	26281	26281	0	
PARTIAL WATER SUPPLY	AC	26000	23611	23611	23611	23611	23611	23611	0	
WETLAND	AC	1115	1115	1115	1115	1115	1115	1115	0	
PHREATOPHYTE	AC	0	0	0	0	0	0	0	0	
COTTONWOOD	AC	208	208	208	208	208	208	208	0	
PRIME LAND	AC	16000	16000	49892	49892	49892	49892	49892	0	
PROJECTS										
CLEAN CANAL	MI	.00	.00	.00	.00	.00	.00	.00	.00	.
CONSTRUCTION COST PER MI	$	0	0	0	0	0	0	0	0	
CONSTRUCTION COST	$	0	0	0	0	0	0	0	0	
INSTALLATION COST	$	0	0	0	0	0	0	0	0	
ANNUAL INSTALLATION COST	$	0	0	0	0	0	0	0	0	
O AND M	$	0	0	0	0	0	0	0	0	
CANAL LINING	MI	.00	.00	.00	4.00	6.60	4.00	.00	.00	.
CONSTRUCTION COST PER MI	$	0	0	0	404390	404390	404390	0	0	
CONSTRUCTION COST	$	0	0	0	1617560	2668974	1617560	0	0	
INSTALLATION COST	$	0	0	0	2119004	3496356	2119004	0	0	
ANNUAL INSTALLATION COST	$	0	0	0	204902	338089	204902	0	0	
O AND M	$	0	0	0	32351	53379	32351	0	0	
CANAL PIPELINE	MI	.00	.00	.00	.00	.00	.00	.00	.00	.
CONSTRUCTION COST PER MI	$	0	0	0	0	0	0	0	0	
CONSTRUCTION COST	$	0	0	0	0	0	0	0	0	
INSTALLATION COST	$	0	0	0	0	0	0	0	0	
ANNUAL INSTALLATION COST	$	0	0	0	0	0	0	0	0	
O AND M	$	0	0	0	0	0	0	0	0	
DIVERSION STRUCTURES	NO	.00	.00	.00	.00	.00	.00	.00	.00	.1
CONSTRUCTION COST PER NO	$	0	0	0	0	0	0	0	0	
CONSTRUCTION COST	$	0	0	0	0	0	0	0	0	
INSTALLATION COST	$	0	0	0	0	0	0	0	0	
ANNUAL INSTALLATION COST	$	0	0	0	0	0	0	0	0	
O AND M	$	0	0	0	0	0	0	0	0	
CANAL CONTROL STRUCTURES	NO	.00	.00	.00	3.00	3.00	3.00	.00	.00	.0
CONSTRUCTION COST PER NO	$	0	0	0	10300	10300	10300	0	0	
CONSTRUCTION COST	$	0	0	0	30900	30900	30900	0	0	
INSTALLATION COST	$	0	0	0	40479	40479	40479	0	0	
ANNUAL INSTALLATION COST	$	0	0	0	3914	3914	3914	0	0	
O AND M	$	0	0	0	618	618	618	0	0	
ON-FARM DITCH LINING	MI	.00	.00	.00	20.00	20.00	.00	20.00	.00	.0
CONSTRUCTION COST PER MI	$	0	0	0	41200	41200	0	41200	0	
CONSTRUCTION COST	$	0	0	0	824000	824000	0	824000	0	
INSTALLATION COST	$	0	0	0	1079440	1079440	0	1079440	0	
ANNUAL INSTALLATION COST	$	0	0	0	104379	104379	0	104379	0	
O AND M	$	0	0	0	16480	16480	0	16480	0	
ON-FARM PIPELINE	MI	.00	.00	.00	5.00	5.00	.00	5.00	.00	.0

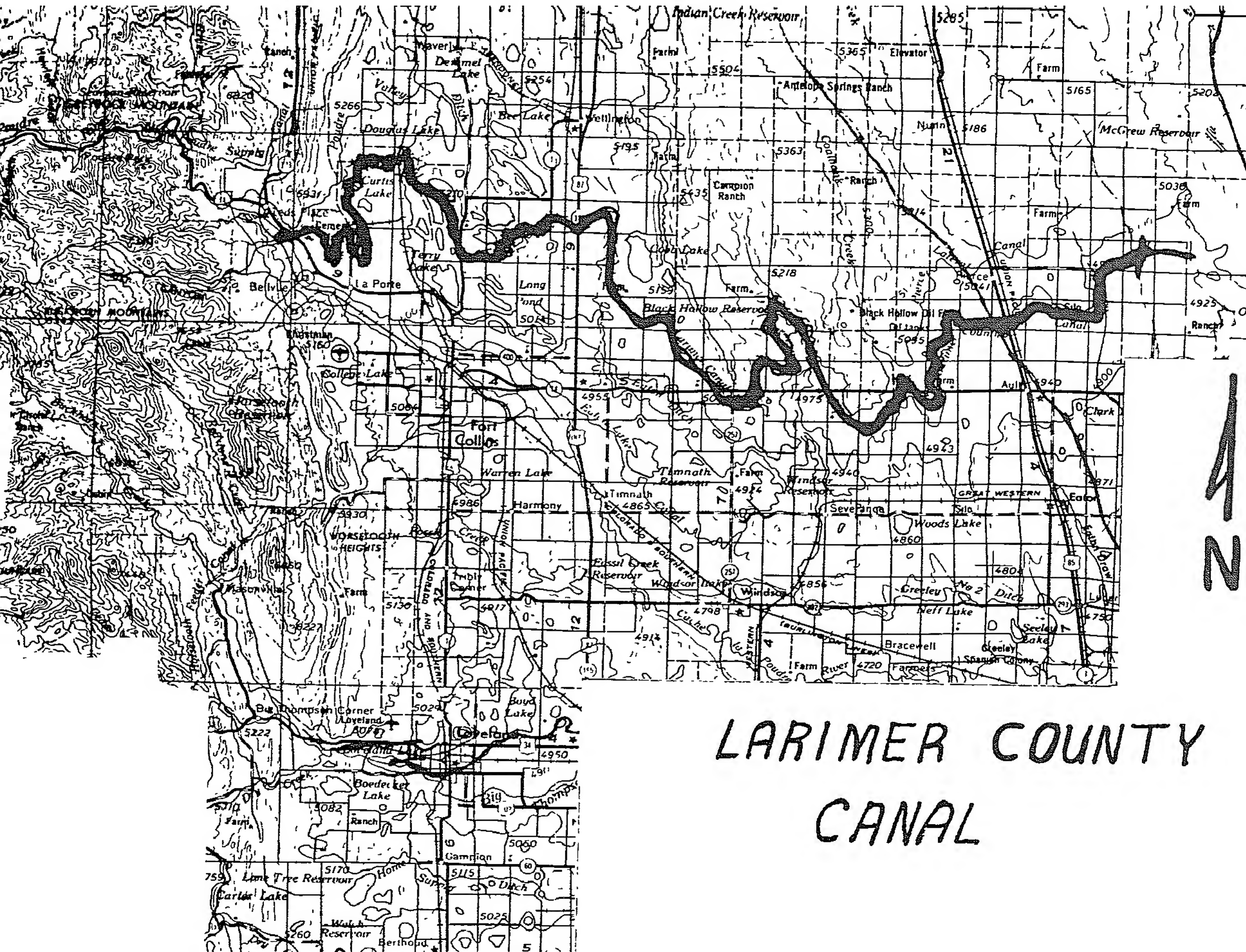
IV
MODEL OUTPUT

		FWOP	FWOP#2	ALT#1	ALT#2	ALT#2M	ALT#3	ALT#4	
CONSTRUCTION COST PER MI	$	0	0	0	62600	62600	0	62600	0
CONSTRUCTION COST	$	0	0	0	313000	313000	0	313000	0
INSTALLATION COST	$	0	0	0	410030	410030	0	410030	0
ANNUAL INSTALLATION COST	$	0	0	0	39649	39649	0	39649	0
O AND M	$	0	0	0	3130	3130	0	3130	0
ON-FARM CONTROL STRUCTURES	NO	.00	.00	.00	100.00	100.00	.00	100.00	.00
CONSTRUCTION COST PER NO	$	0	0	0	3100	3100	0	3100	0
CONSTRUCTION COST	$	0	0	0	310000	310000	0	310000	0
INSTALLATION COST	$	0	0	0	406100	406100	0	406100	0
ANNUAL INSTALLATION COST	$	0	0	0	39269	39269	0	39269	0
O AND M	$	0	0	0	6200	6200	0	6200	0
LAND LEVELING	AC	.00	.00	.00	1000.00	1000.00	.00	1000.00	.00
CONSTRUCTION COST PER AC	$	0	0	0	600	600	0	600	0
CONSTRUCTION COST	$	0	0	0	600000	600000	0	600000	0
INSTALLATION COST	$	0	0	0	786000	786000	0	786000	0
ANNUAL INSTALLATION COST	$	0	0	0	76004	76004	0	76004	0
O AND M	$	0	0	0	12000	12000	0	12000	0
ON-FARM DRAINING	AC	.00	.00	.00	.00	.00	.00	.00	.00
CONSTRUCTION COST PER AC	$	0	0	0	0	0	0	0	0
CONSTRUCTION COST	$	0	0	0	0	0	0	0	0
INSTALLATION COST	$	0	0	0	0	0	0	0	0
ANNUAL INSTALLATION COST	$	0	0	0	0	0	0	0	0
O AND M	$	0	0	0	0	0	0	0	0
RESERVOIR IMPROVEMENT	NO	.00	.00	.00	.00	.00	.00	.00	.00
CONSTRUCTION COST PER NO	$	0	0	0	0	0	0	0	0
CONSTRUCTION COST	$	0	0	0	0	0	0	0	0
INSTALLATION COST	$	0	0	0	0	0	0	0	0
ANNUAL INSTALLATION COST	$	0	0	0	0	0	0	0	0
O AND M	$	0	0	0	0	0	0	0	0
IRRIGATION WATER MANAGEMENT	AC	.00	.00	49892.00	49892.00	49892.00	.00	.00	.00
CONSTRUCTION COST PER AC	$	0	0	62	62	62	0	0	0
CONSTRUCTION COST	$	0	0	3095799	3095799	3095799	0	0	0
INSTALLATION COST	$	0	0	4055496	4055496	4055496	0	0	0
ANNUAL INSTALLATION COST	$	0	0	392157	392157	392157	0	0	0
O AND M	$	0	0	0	0	0	0	0	0
CONVERSION OF IRRIGATION METHOD	AC	.00	.00	.00	3000.00	3000.00	.00	3000.00	.00
CONSTRUCTION COST PER AC	$	0	0	0	0	0	0	0	0
CONSTRUCTION COST	$	0	0	0	0	0	0	0	0
INSTALLATION COST	$	0	0	0	0	0	0	0	0
ANNUAL INSTALLATION COST	$	0	0	0	0	0	0	0	0
O AND M	$	0	0	0	0	0	0	0	0
CONSERVATION CROPPING SYSTEM	AC	.00	.00	.00	.00	.00	.00	.00	.00
CONSTRUCTION COST PER AC	$	0	0	0	0	0	0	0	0
CONSTRUCTION COST	$	0	0	0	0	0	0	0	0
INSTALLATION COST	$	0	0	0	0	0	0	0	0
ANNUAL INSTALLATION COST	$	0	0	0	0	0	0	0	0
O AND M	$	0	0	0	0	0	0	0	0
PHREATOPHYTE ERADICATION	AC	.00	.00	.00	.00	.00	.00	.00	.00
COST PER AC	$	0	0	0	0	0	0	0	0
COST	$	0	0	0	0	0	0	0	0
ANNUAL COST	$	0	0	0	0	0	0	0	0
COTTONWOOD ERADICATION	AC	.00	.00	.00	.00	.00	.00	.00	.00
COST PER AC	$	0	0	0	0	0	0	0	0
COST	$	0	0	0	0	0	0	0	0
ANNUAL COST	$	0	0	0	0	0	0	0	0
WETLAND ERADICATION	AC	.00	.00	.00	.00	.00	.00	.00	.00
COST PER AC	$	0	0	0	0	0	0	0	0

		.00	.00	.00	.00	.00	.00	.00	.00
COST PER AC	$	0	0	0	0	0	0	0	0
COST	$	0	0	0	0	0	0	0	0
ANNUAL COST	$	0	0	0	0	0	0	0	0
WETLAND HABITAT MANAGEMENT	AC	.00	.00	.00	.00	.00	.00	.00	.00
COST PER AC	$	0	0	0	0	0	0	0	0
COST	$	0	0	0	0	0	0	0	0
ANNUAL COST	$	0	0	0	0	0	0	0	0
TOTAL CONSTRUCTION COST	$	0	0	3095799	6791259	7842673	1648460	2047000	0
TOTAL INSTALLATION COST	$	0	0	4055496	8896549	10273901	2159483	2681570	0
TOTAL ANNUAL INSTALLATION COST	$	0	0	392157	660274	993461	208117	259301	0
TOTAL O AND M	$	0	0	0	70779	91807	32769	37810	0
ANNUAL CROP PRODUCTION BENEFITS	$	0	269205	951401	1286568	1356409	381099	451903	0
ANNUAL NET BENEFITS	$	0	269205	559244	355514	271140	139313	154791	0
BENEFIT / COST RATIO		.000	.000	2.426	1.382	1.250	1.576	1.521	.000
PRODUCTION VALUES-------------------									
TOTAL PRODUCTION VALUE	$	15687675	16474145	17752751	18412797	18558751	16695166	15935123	0
PRODUCTION VALUES									
ALFALFA	$	4384408	4389795	5581202	5745267	5883222	4610816	4750673	0
CORN	$	13683267	11663594	12246774	12246774	12246774	11663594	11663594	0
PASTURE	$	700000	420756	420756	420756	420756	420756	420756	0
NET RETURNS FROM CROPS	$	5383589	5652294	6334492	6669657	6739497	5764127	5934991	0
YIELDS-------------------------------									
ALFALFA	T/AC	3.77	3.43	3.97	4.49	4.68	3.62	3.71	.00
CORN	BU/AC	140.00	140.00	147.00	147.00	147.00	140.00	140.00	.00
PASTURE	AM/AC	7.00	7.00	7.00	7.00	7.00	7.00	7.00	.00
WATER ACCOUNTING--------------------									
DIVERSION WATER									
APRIL	ACFT	292	292	292	292	292	292	292	0
MAY	ACFT	4199	4199	4199	4199	4199	4199	4199	0
JUNE	ACFT	10613	10613	10613	10613	10613	10613	10613	0
JULY	ACFT	12997	12997	12997	12997	12997	12997	12997	0
AUGUST	ACFT	10856	10856	10856	10856	10856	10856	10856	0
SEPTEMBER	ACFT	4303	4303	4303	4303	4303	4303	4303	0
OCTOBER	ACFT	1740	1740	1740	1740	1740	1740	1740	0
TOTAL	ACFT	45000	45000	45000	45000	45000	45000	45000	0
WITHDRAWN TO RESERVOIR STORAGE									
APRIL	ACFT	0	0	0	0	0	0	0	0
MAY	ACFT	0	0	0	0	0	0	0	0
JUNE	ACFT	0	0	0	0	0	0	0	0
JULY	ACFT	0	0	0	0	0	0	0	0
AUGUST	ACFT	0	0	0	0	0	0	0	0
SEPTEMBER	ACFT	0	0	0	0	0	0	0	0
OCTOBER	ACFT	0	0	0	0	0	0	0	0
TOTAL	ACFT	0	0	0	0	0	0	0	0
EVAPORATION	ACFT	0	0	0	0	0	0	0	0
OTHER WATER									
APRIL	ACFT	0	0	0	0	0	0	0	0
MAY	ACFT	0	0	0	0	0	0	0	0
JUNE	ACFT	0	0	3015	8202	9088	0	0	0
JULY	ACFT	14015	12984	16841	17920	17107	13844	13856	0
AUGUST	ACFT	21498	24733	21595	7254	6778	22809	21995	0
SEPTEMBER	ACFT	16488	14282	16148	18624	19028	15346	16148	0
OCTOBER	ACFT	0	0	0	0	0	0	0	0
TOTAL	ACFT	52000	52000	52000	52000	52000	52000	52000	0

IV
MODEL OUTPUT

	FWOP	FWOP#2	ALT#1	ALT#2	ALT#2M	ALT#3	ALT#4		
CONVEYANCE SYSTEM EFFICIENCY	%	70.00	70.00	70.00	76.00	74.00	70.00	.00	.00
CANAL SEEPAGE	ACFT	29100	29100	29100	23280	25220	29100	0	0
CANAL SEEPAGE TO GROUNDWATER	ACFT	26190	26190	26190	20952	22698	26190	0	0
CANAL SEEPAGE TO RETURN FLOWS	ACFT	2910	2910	2910	2328	2522	2910	0	0
SURFACE WATER DELIVERED TO FARM	ACFT	67900	67900	67900	73720	71780	67900	0	0
GROUNDWATER PUMPED									
APRIL	ACFT	0	0	0	0	0	0	0	0
MAY	ACFT	0	0	0	0	0	0	0	0
JUNE	ACFT	2595	0	0	0	1123	2111	0	0
JULY	ACFT	5357	7952	7952	0	6829	5841	0	0
AUGUST	ACFT	0	0	0	7952	0	0	0	0
SEPTEMBER	ACFT	0	0	0	0	0	0	0	0
OCTOBER	ACFT	0	0	0	0	0	0	0	0
TOTAL	ACFT	7952	7952	7952	7952	7952	7952	0	0
TOTAL WATER ON FARM	ACFT	75852	75852	75852	81672	79732	75852	0	0
ON-FARM EFFICIENCY	%	48.00	48.00	52.00	56.00	48.00	52.00	.00	.00
WATER SURPLUS OR DEFICIT TO TOTAL CROP CONSUMPTIVE USE FROM DIVERSION, OTHER AND GROUNDWATER									
APRIL	ACFT	-193	-76	-68	-50	-71	-68	0	0
MAY	ACFT	-3055	-2803	-2685	-2427	-2722	-2685	0	0
JUNE	ACFT	-8219	-9329	-7934	-4510	-8586	-7934	0	0
JULY	ACFT	-12901	-12290	-12025	-12025	-12025	-12025	0	0
AUGUST	ACFT	-11121	-10316	-10316	-10316	-10316	-10316	0	0
SEPTEMBER	ACFT	-4815	-5655	-4455	-1970	-4920	-4455	0	0
OCTOBER	ACFT	-446	-121	-72	34	-88	-72	0	0
SURPLUS	ACFT	0	0	0	34	0	0	0	0
DEFICIT	ACFT	-40754	-40596	-37562	-31303	-38734	-37562	0	0
TOTAL CROP CONSUMPTIVE USE	ACFT	38966	39290	42267	48435	41114	42267	0	0
SURFACE RETURN FLOWS FROM FARM	ACFT	5916	5916	5461	5390	6219	5461	0	0
PERCOLATION TO GROUNDWATER FARM	ACFT	33527	33527	30948	30545	35242	30948	0	0
TOTAL GROUNDWATER RECHARGE	ACFT	59717	59717	57138	51497	57940	57138	0	0
PHREATOPHYTE, WETLAND AND COTTONWOOD WITHDRAWAL FROM GROUNDWATER	ACFT	3633	3633	3633	3633	3633	3633	0	0
NET GAIN OR LOSS TO GROUNDWATER	ACFT	56084	56084	53505	47864	54307	53505	0	0
TOTAL SURFACE WATER RETURN FLOWS	ACFT	8826	8826	8371	7718	8741	8371	0	0
DISSOLVED SALTS IN WATER-------------									
SALT IN SURFACE RETURN FLOWS	TONS	17618	17618	16709	15406	17447	16709	0	0
SALT IN GROUNDWATER RECHARGE	TONS	119358	119358	114204	102930	115807	114204	0	0
SALT IN PUMPWATER	TONS	15894	15894	15894	15894	15894	15894	0	0
NET SALT IN GROUNDWATER	TONS	103464	103464	98310	87036	99913	98310	0	0



LARIMER COUNTY CANAL

APPENDIX K

Glossary

Amortized: The extinguishing of a financial obligation in equal installments is called amortization. The amortization factor is the amount of the installment required to retire a debt of $1.00 in a given length of time at a given interest rate.

Annual Crop Production Benefits: The amount of increase in net returns from crops (without project costs) brought about by project action through increased crop yields or acreage of decreased production costs minus Future Without Project benefits.

Annual Installation Cost: Expenditures for initial construction of the resource improvement. These costs will include estimates for construction and may include engineering services, land rights, project administration and legal fees. These cost are then amortized to yearly equal payments.

Annual Man Year: Work produced by one person working eight hours per day and 250 days per year.

Annual Net Benefits: Annual gross returns less annual costs including the annual cost incurred from some action (such as a project) as resulting from the action taken, such as a project. Annual net benefits = Annual crop production benefits - total annual installation cost - total annual operation and maintenance.

Benefit/Cost Ratio:

$$\frac{\text{Annual Net Benefits}}{\text{Total Annual Installation Costs + Total Operation and Maintenance}}$$

An economic indicator of the efficiency of a proposed project, computed by dividing benefits by costs; usually, both the benefits and costs are discounted so that the ratio reflects efficiency in terms of the present value of future benefits and costs.

Canal Control Structures: Structures in an irrigation canal system that convey water, control the direction or rate of flow, or maintain a desired water surface elevation.

Canal Lining: A fixed lining of impervious material installed in an existing or newly constructed irrigation canal.

Canal Pipeline: A pipeline and appurtenances in an irrigation canal system.

Canal Seepage: The volume of water that seeps from the canal into the subsurface.

Canal Seepage to Groundwater: The volume of water that seeps from the canal into the ground water system.

Canal Seepage to Return Flows: The volume of water that seeps from the canal into the subsurface and then surfaces in drains and streams.

Canal Systems: Conveyance system and irrigation cropland served by that system.

Clean-Canal: Removing vegetation, sediment, and debris from canal banks, berms, spoil, and associated areas.

Conservation Cropping System: Growing crops by using a combination of needed cultural and management measures. Cropping systems include rotations that contain grasses and legumes, as well as rotations in which the desired benefits are achieved without the use of such crops.

Construction Cost: Engineers cost estimate of the project plus 15 percent added for contingencies.

Conversion of Irrigation Method: The onfarm changing from one irrigation method to another, ie, border to sprinkler.

Conveyance System: A permanent irrigation canal or lateral constructed to convey water from the source of supply to one or more farms.

Conveyance System Efficiency: The volume of water delivered to the farm, expressed as a ratio or percent, of the volume of water diverted (gross diversion) from a stream or other water supply.

Cost Effective Crop: A crop which indicates a positive net benefit after all project costs are considered.

Cottonwood: A water consuming phreatophyte.

Cottonwood Eradication: Removing the tree as a water conservation practice.

Crop Consumptive Use: The amount of water used by crops in transpiration and building of plant tissue, evaported from adjacent soil, and intercepted precipitation on the plant foliage.

Dissolved Salts In Water: Total dissolved solids in water expressed as a concentration in terms of milligrams per liter (mg/l) or in total tons in a specified volume of water.

Diversion Structure: A structure built to divert part or all the water from a river or a stream into a different water course or irrigation canal or ditch.

Diversion Water: That amount of water turned into a conveyance system.

Engineering Practices: Structures which are designed, constructed and used in a soil and water conservation or management system to retain, regulate or control the flow of water.

Engineering Services: A cost of services provided and calculated at fourteen percent of construction cost.

Environmental Practices: Conservation practices which improve the environmental quality.

Environmental Quality (E.Q.): The creation, management, or preservation of areas of natural beauty, quality of water, land and air, biological resources and ecosystems, geological, archaeological, and historical resources.

Evaporation: That part of the water supply lost to the atmosphere as vapors.

Full Water Supply: Croplands that have sufficient water to meet their needs.

Ground Water Pumped: Water removed from the ground water system by pumping.

Ground Water Recharge: Canal seepage and on-farm percolation of water into the ground water system.

Interruption of Irrigation Services: Damage to a conveyance system from breach or failures that would prevent irrigation water from reaching the farm.

Irrigation Efficiencies: The percent of water diverted that is consumptively used by crops. This is a combination of conveyance efficiency and on-farm efficiency.

Irrigation Shortage: An amount of water needed but not available to crops (water short).

Irrigation Surplus: An amount of water surplus to crop needs.

Irrigation Water Management (IWM): Controlling or regulating water application in a way that insures high crop yields without wasting water, soil, or plant nutrients. It means applying water according to crop needs in amounts that can be held in the soil available to crops and at rates consistent with the intake characteristics of the soil and the erosion hazard to the site.

Installation Cost: Total cost of construction, engineering services, project administration, and land rights.

Land Leveling: Reshaping the surface of land to be irrigated to planned grades.

Linear Programming Techniques: A mathematical technique designed to maximize something (usually profit) or to minimize something (usually costs) subject to a set of limitations such as land, water, etc.

Model: A mathematical formulation such as linear programming water budgeting, etc.

Net Returns from Crops: Total production value less production costs.

On Farm Control Structures: A structure in an on-farm irrigation system that conveys water, controls the direction or rate of flow, or maintains a desired wate surface elevation.

On Farm Ditch Lining: A fixed lining of impervious material installed in an existing or newly constructed irrigation ditch.

On Farm Draining: A conduit, such as tile, pipe or tubing installed beneath the ground surface to collect, and or convey subsurface water.

On Farm Efficiency: The volume of water stored in the soil root zone and used by the crop. It is expressed as a ratio or percent of the volume of water delivered to the farm and is characterized both by the onfarm distribution system and the field application system.

On Farm Irrigation System: A planned irrigation system where all necessary water control structures have been installed for the efficient distribution of irrigation water by surface means, such as furrows, borders, contour levees, or contour ditches, or by subsurface means.

On Farm Pipeline: A pipeline and appurtenances in an onfarm irrigation system.

Other Water: Reservoir water and water purchased then delivered through the system to the farm.

Partial Water Supply: Croplands that do not have sufficient water to meet their needs (water short).

Percolation to Ground Water from Farm: That part of onfarm applied irrigation water that goes into the ground water system.

Phreatophyte: A plant that depends, for its water supply, upon ground water that lies within reach of its roots. Commonly found along streams or where the water table is close to the land surface.

Phreatophyte Eradication: Removing the plant as a water conservation practice.

Prime Land: Available land that has the best physical and chemical characteristics for producing food, feed, forage, or fiber.

Production Values: Gross returns from crop production.

Project Administration: A cost of administration calculated at 17 percent of the construction cost.

Reservoir Improvement: To do repair work on an existing reservoir.

Reservoir Water: Irrigation water turned into the conveyance system from reservoir storage. This water is supplemental to diverted water. Is shown as "Other water" also.

Salinity Levels: Concentration of total disolved solids in milograms per liter or tons.

Seasonal Evaporation From Reservoirs: Evaporation from water surface areas in Reservoirs for the season, April through October.

Setting Bounds: This applies to setting upper and lower limitations on certain resources and/or production activities in the linear programming model. Examples are acres of crops, land use, and water use.

Short Water Supply: Same as partial water supply.

Soil Association: A mapping unit used on general soil maps in which two or more defined taxonomic units, occurring together in a characteristic pattern, are combined on the map into one unit. The components of the soil association may or may not be contrasting.

Spill Water: That part of diverted water spilled back to the main stream or to a reservoir before reaching the farm.

Surface Return Flows from Farm: This includes on farm tailwater flows.

Surface Water Delivered to Farms: That amount of diverted water, reservoir water, and purchased water reaching the farm.

Total Operation and Maintenance Cost: These represent the annual values of materials, equipment and services needed to operate the resource improvement, and to make repairs and replacement necesary to maintain the facilities in sound operating conditions during their economic life.

Total Production Value: Gross value of crops grown.

Upland Habitat Management: Retaining, creating, or managing an area other than wetland for food an shelter for wildlife.

Water Accounting: An accounting of water diversions, uses, and return flows.

Water Deficit: Same as irrigation shortage (water short).

Water Surplus: Same as irrigation surplus.

Wetlands: Lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface.

Wetland Eradication: Removal of the water table to allow the wetlands to be converted to cropland.

Wetland Habitat Management: Retaining, creating, or managing wetland habitat for wildlife.

Yields: Crop yields in terms of units per acre. Units consist of such measures and bushels, hundredweight and tons.